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**BASELINE RISK ASSESSMENT
FOR THE H.O.D. LANDFILL SITE
ANTIOCH, ILLINOIS**

 **ICF KAISER**



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August 31, 1994

Mr. Fred Micke
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RE: H.O.D. Landfill NPL Site
Transmittal of Baseline Risk Assessment

Dear Mr. Micke:

On behalf of Waste Management of Illinois, Inc. (WMI), ICF Kaiser Engineers, Inc. and Weinberg Consulting Group, Inc. are submitting three copies of the Baseline Risk Assessment for the H.O.D. Landfill National Priorities List (NPL) Site. Two copies of the Baseline Risk Assessment have been submitted to Mr. Greg Ratliff of the Illinois Environmental Protection Agency by copy of this letter. If you have any questions, please contact Sarah Foster at (202) 833-8077.

Sincerely,

William Mendez, PhD
Chief Scientist

Enclosures

Baseline Risk Assessment (three copies)

cc: Mr. Greg Ratliff (two copies)
Ms. Lydia Kuyawa (three copies)
Mr. Martin Hamper (one copy)
Ms. Sarah Foster (one copy)

BASELINE RISK ASSESSMENT FOR THE H.O.D. LANDFILL SITE ANTIOCH, ILLINOIS

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August 31, 1994

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EXECUTIVE SUMMARY

The H.O.D. Landfill was opened for operation in 1963 and closed in 1984. While in operation, the landfill received municipal, industrial, and special wastes. On February 21, 1990, the H.O.D. Landfill site was listed on the National Priorities List (NPL). Waste Management of Illinois, Inc. (WMI) retained Warzyn Inc. (Warzyn) to perform the Remedial Investigation (RI) for the site. Sampling of the site was conducted in accordance with work plans prepared by Warzyn and WMI, and approved by USEPA Region V, in May-July 1993 and March 1994. The sampling focused on surface soil, surface water, sediment, groundwater, private wells, municipal wells, leachate and landfill gas. One component of the RI is a Baseline Risk Assessment (Baseline RA), which was conducted for this site by ICF Kaiser Engineers and the WEINBERG CONSULTING GROUP Inc. This Baseline RA is presented in this document.

The Baseline RA was conducted in accordance with Subpart E, Section 300.430(d) of the revised National Contingency Plan (NCP) as promulgated on March 8, 1990 (USEPA 1990). It was conducted to characterize the current or potential threat to public health and the environment that may be posed by chemicals originating at or migrating from the H.O.D. Landfill site in the absence of remedial (corrective) action. The no-action alternative was evaluated in accordance with the NCP.

In addition to following the 1990 NCP, this Baseline RA was conducted in accordance with more recent USEPA guidance on presumptive remedies for municipal landfill sites (USEPA 1993). The presumptive remedy approach streamlines the process of identifying the need for, and nature and extent of, landfill site remediation. Through discussions with USEPA Region V, the presumptive remedy guidance was interpreted to mean that the H.O.D. Landfill Baseline RA need not evaluate potential risks to a hypothetical future on-site resident. Rather, the need for on-site remediation was assessed in the Baseline RA by comparing on-site groundwater concentrations to Safe Drinking Water Act Maximum Contaminant Levels (MCLs), non-zero MCL Goals (MCLGs), and available Illinois drinking water standards. Consistent with a more traditional approach, the Baseline RA also addressed potential human health and environmental impacts associated with the presence or possible migration of site-related chemicals from the landfill.

In general, this risk assessment followed relevant guidance and standards developed by the USEPA (1986a,b, 1989a,b, 1991a, 1992a,b). This Baseline RA also was based on a Technical Work Plan for the H.O.D. Landfill Baseline Risk Assessment (ICFKE 1993, USEPA 1994a,b,c, WEINBERG GROUP

1994, WMII 1994) which was approved by USEPA Region V in June 1994. The inclusion of approaches and values specified by USEPA Region V, however, should not be construed to imply any independent verification or concurrence on the part of WMII or its contractors.

The Baseline RA was based on data and information regarding the site and surrounding area obtained primarily during the RI and during a site visit. Using this information, the first step of the assessment was to select chemicals of potential concern for detailed evaluation. This was conducted by considering the presence of chemicals in blank samples, summarizing and evaluating the RI data, and including a consideration of naturally occurring background levels in soil and groundwater. Based on these evaluations, 47 chemicals of potential concern were selected for detailed assessment. These chemicals include those most likely to be of concern to human health and the environment, but also include chemicals selected by default because no background data was available in some cases.

For each chemical of potential concern, quantitative toxicity criteria used to calculate risks was compiled. The toxicity criteria were primarily obtained from USEPA's Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEASTs).

An exposure assessment was then conducted to identify potential pathways of concern to human health. The following pathways were selected for detailed evaluation:

- Incidental ingestion of on-site surface soil by trespassers on the site,
- Dermal absorption of chemicals in on-site surface soil by trespassers on the site,
- Dermal absorption of chemicals in Sequoit Creek surface water by trespassers on the site,
- Incidental ingestion of Sequoit Creek sediment by trespassers on the site,
- Dermal absorption of chemicals in Sequoit Creek sediment by trespassers on the site,
- Groundwater ingestion from public supply wells by nearby adult residents,
- Groundwater ingestion from private wells by nearby adult residents,
- Groundwater ingestion from off-site groundwater monitoring wells by nearby adult residents (surficial sand and the deep sand and gravel aquifers),
- Inhalation of volatile organic chemicals while showering with groundwater from public supply wells by nearby adult residents,

- Inhalation of volatile organic chemicals while showering with groundwater from the off-site deep sand and gravel aquifer by nearby adult residents,
- Dermal absorption while showering with groundwater from public supply wells by nearby adult residents,
- Dermal absorption while showering with groundwater from private wells by nearby adult residents,
- Dermal absorption while showering with off-site groundwater (surficial sand and the deep sand and gravel aquifer) by nearby adult residents,
- Inhalation of volatile organic chemicals emitted from the landfill surface by nearby residents.

Exposures by each of these pathways were then calculated. In accordance with USEPA guidance, the Baseline RA examined a reasonable maximum exposure (RME) associated with each pathway of concern. The NCP defines "reasonable maximum" such that "only potential exposures that are likely to occur will be included in the assessment of exposure" (USEPA 1990). USEPA risk assessment guidance further defines the RME to be "the highest exposure that is reasonably expected to occur at a site" (USEPA 1989a). The RME is intended to place a conservative upper bound on the potential risks, meaning that the risk estimate is unlikely to be underestimated but it may be overestimated. The likelihood that an RME scenario may actually occur is probably small, due to the many conservative assumptions incorporated into the reasonable maximum exposure scenario.

In the next step, chemical concentrations at the potential points of exposure (exposure point concentrations) were calculated and combined with information on the magnitude, frequency and duration of potential exposures. The exposure point concentrations were based on the RI data where possible, following the approach recommended in USEPA's Risk Assessment Guidance for Superfund [the 95th upper confidence limit (UCL) on the arithmetic mean concentration or the maximum, whichever was less]. Mathematical models were used to estimate exposure point concentrations in indoor air while showering and in ambient air from landfill gas emissions. The exposure point concentrations represent a major source of uncertainty in the Baseline RA, since in many cases the single maximum detected concentration at one location was used to evaluate long-term risks (since the 95th UCL exceeded the maximum concentration in many cases). The use of a maximum concentration is unlikely to reflect a reasonable maximum exposure scenario. Modeled concentrations, particularly those associated with landfill gas emissions, also are associated with uncertainty due to the choice of models as well as input parameters.

In the next step, intake parameters were combined with the exposure point concentrations. The intake parameters were primarily based on conservative values specified by USEPA in guidance documents. In the absence of such values, exposure parameter information was derived from the scientific literature.

Potential RME risks for each selected pathway were then calculated. These risks are summarized in Table E-1. The table indicates the upper-bound excess lifetime cancer risks and the hazard index values associated with the noncarcinogenic chemicals. These upper bound lifetime cancer risk values and hazard index values can be put into context by considering USEPA's OSWER Directive 9335.0-30 (USEPA 1991b) as follows:

Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4} , and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts. However, if MCLs or non-zero MCLGs are exceeded, action generally is warranted.

Table E-1 shows that excess lifetime cancer risks for the RME case exceed 10^{-4} ($1\text{E-}04$) for only one chemical in one pathway, ingestion of vinyl chloride from off-site deep sand and gravel aquifer groundwater. These risk estimates conservatively assume that an individual would be exposed to the maximum detected concentration of vinyl chloride in one well 350 days/year for 30 years, even though there is no actual current use of water from the off-site deep sand and gravel monitoring wells. The excess lifetime cancer risks from inhalation and dermal absorption of vinyl chloride while showering with off-site deep sand and gravel groundwater collectively add a risk of 9×10^{-5} to the ingestion risk of 8×10^{-4} . The available groundwater data do not, however, conclusively indicate a clear pattern of association of vinyl chloride with the site, since this chemical was detected infrequently and at lower concentrations in leachate (1 out of 5 samples at 18 ug/L) and on-site surficial sand groundwater (1 out of 12 samples at 19 ug/L) compared to off-site deep sand and gravel groundwater (2 out of 4 samples at 28 ug/L and 35 ug/L). Vinyl chloride was not detected in on-site deep sand and gravel groundwater or in off-site surficial sand groundwater. Vinyl chloride is, however, a common byproduct at waste landfills and is present in the site's on-site surficial sand groundwater and landfill gas samples.

A few other chemicals had excess lifetime cancer risks greater than 1×10^{-6} ($1\text{E-}06$) or had a hazard

index greater than one.

- beryllium - ingestion and dermal absorption while showering with off-site surficial sand and gravel aquifer groundwater,
- arsenic - ingestion of municipal well water, and
- manganese - ingestion of off-site surficial sand groundwater.

These results should be considered in context with their associated important uncertainties.

- Beryllium was selected as a chemical of concern in off-site surficial sand groundwater because no background dissolved groundwater data were available. It was only detected in 1 of 4 samples from off-site surficial sand groundwater at a concentration of 0.95 ug/L. Beryllium was not, however, detected in on-site surficial sand or deep sand and gravel groundwater, or in off-site deep sand and gravel groundwater. It was detected in 1 of 34 regional background samples (total not dissolved) at a concentration of 1 ug/L. These data suggest that beryllium may not be a site-related chemical. In addition, there is no actual current use of water from the off-site surficial sand monitoring wells.
- Arsenic was selected as a chemical of concern in municipal wells because fewer than 3 samples were available, and thus, according to USEPA Region V direction for this risk assessment, the chemical was selected by default. The two detected concentrations of arsenic in municipal well samples, 2.1 ug/L and 4.3 ug/L, are well below the federal MCL of 50 ug/L and below the range of regional background levels of 1- 26 ug/L. These conclusions, in conjunction with the fact that arsenic was not a selected chemical of concern in any other groundwater data set, indicate that arsenic is not a site-related chemical.
- The manganese concentration in the off-site surficial sand groundwater used to calculate long-term risks was the single maximum detected value in one well. The manganese concentrations detected in the other off-site surficial sand monitoring wells were all at least ten times lower than the maximum. All of the detected manganese concentrations in off-site surficial sand groundwater wells were less than the levels at which minor neurological effects (based on neurologic exam scores) have been observed in individuals chronically exposed to manganese in drinking water (Kondakis et al. 1989). Also, there is no actual current use of water from the off-site surficial sand monitoring wells.

- The method used to calculate risks from dermal exposure to water while showering for beryllium and vinyl chloride is very uncertain. It is based on an unvalidated model presented in an "Interim Report" prepared by USEPA for assessing dermal risks (USEPA 1992b). Further, since there are no toxicity data available based on the dermal route of exposure, the use of oral toxicity data to evaluate this pathway adds uncertainty to the results.

In accordance with the Technical Workplan for the H.O.D. Landfill Risk Assessment, the concentrations of chemicals in on-site groundwater were compared to federal and state standards and guidelines. Thallium was present in on-site deep sand and gravel groundwater at levels exceeding the federal MCLG and similar to the federal MCL and Illinois groundwater quality standard. However, these results are based on only a single detection (out of 3 samples) of thallium in this aquifer dataset. Thallium was not detected in any of the other groundwater data sets. Manganese was present at levels in on-site surficial sand groundwater above the federal MCLG and Illinois standard. Vinyl chloride was also detected once (out of 12 samples) in on-site surficial sand groundwater at a level above the federal MCL and Illinois standard.

An ecological risk assessment was also conducted to evaluate potential impacts on nonhuman receptors associated with the site. This evaluation involved the identification of potential receptors and exposure pathways, including determination of the presence of endangered or threatened species in the area. Potential risks to aquatic life were evaluated by comparison with ambient water quality criteria and sediment guidance values (Long and MacDonald 1992). Potential risks to terrestrial plants and wildlife were evaluated by extrapolation of site-specific habitat and chemistry information and literature-based toxicity data to estimate exposure, toxicity, and risk. Overall, the ecological assessment was largely qualitative since the occurrence and concentration of chemicals at the site are such that a more detailed analysis is not supported or warranted. This assessment was consistent with USEPA Region V (USEPA 1992c) guidance Step 2. The ecological evaluation showed that potential risks to plants, aquatic life, and terrestrial wildlife are estimated to be minimal. Visual observations of the character and composition of the terrestrial and aquatic communities of the site suggest a relatively "healthy" community. These observations combined with predictions of low exposure and risk support the conclusion that biological populations and communities of the area have not been adversely affected by chemicals present at or migrating from the H.O.D. Landfill site.

TABLE E-1
SUMMARY OF RISK ASSESSMENT RESULTS
H.O.D. LANDFILL

EXPOSURE PATHWAY	RME EXCESS LIFETIME CANCER RISK	PREDOMINANT CHEMICALS (a)	RME HAZARD INDEX	PREDOMINANT CHEMICALS (b)
CHILD/TEENAGE SITE TRESPASSER				
Incidental surface soil ingestion	4E-09	NA	<1 (7E-05)	NA
Dermal absorption from surface soil	5E-09	NA	<1 (1E-04)	NA
Dermal contact with surface water	NE	NA	<1 (5E-03)	NA
Incidental sediment ingestion	1E-08	NA	<1 (2E-04)	NA
Dermal absorption from sediment	4E-11	NA	<1 (1E-05)	NA
Direct contact with carcinogenic PAHs				
Surface soil	Cancer risk not likely	NA	NA	NA
Sediment	Cancer risk not likely	NA	NA	NA
NEARBY ADULT RESIDENT				
Ingestion of groundwater				
Off-site surficial sand	5E-05	Beryllium	>1 (6)	Manganese
Off-site deep sand and gravel	8E-04	Vinyl Chloride	<1 (9E-01)	NA
Municipal wells	9E-05	Arsenic	<1 (5E-01)	NA
Private wells	NE	NA	<1 (8E-02)	NA
NEARBY ADULT RESIDENT (Cont.)				
Inhalation of volatiles while showering				
Off-site deep sand and gravel	6E-05	Vinyl Chloride	NE	NA
Municipal wells	5E-07	NA	<1 (2E-03)	NA
Dermal absorption while showering				
Off-site surficial sand	2E-05	Beryllium	<1 (2E-01)	NA
Off-site deep sand and gravel	3E-05	Vinyl Chloride	<1 (4E-02)	NA
Municipal wells	2E-07	NA	<1 (7E-03)	NA
Private wells	NE	NA	<1 (4E-04)	NA
Inhalation of volatiles from ambient air	5E-07	NA	<1 (3E-04)	NA

NA = Not applicable.

NE = Not evaluated since chemicals relevant for this health endpoint were not selected or detected in this data grouping.

(a) Predominant chemicals are those with RME cancer risk greater than 1E-06 (1 in 1,000,000).

(b) Predominant chemicals are those with RME hazard quotients greater than 1.

1.0 INTRODUCTION

The H.O.D. Landfill is located in the Village of Antioch in Lake County in northeastern Illinois which is approximately 50 miles north-northwest of Chicago, Illinois. The landfill consists of adjacent "old" and "new" landfill areas which cover 51 acres of the 80 acres site (see Figures 1-1 and 1-2). Waste disposal activities began at the H.O.D. Landfill in 1963. Operations at the "old" landfill consisted of disposal of waste in trenches with cover applied on an irregular basis to prevent blowing litter and to control odors. Operation of the "new" landfill began with the installation of a clay barrier wall between the "old" and "new" sections of the landfill. A leachate collection system was also installed along the eastern boundary of the "old" landfill and within the "new" landfill. The floor and walls of the "new" landfill consist of clay - when materials other than native clay soil were encountered, they were removed and replaced with six to twelve feet of compacted clay. The entire site was closed in 1984 (Warzyn, 1992).

In July 1984, the United States Environmental Protection Agency (USEPA) conducted a site investigation at the landfill. The results of the investigation were used in conjunction with other information to rank the site in April 1985 under the Hazard Ranking System (HRS). The calculated HRS score was 52.02. Based on this HRS ranking, the site was proposed by USEPA for inclusion on the National Priorities List (NPL) on September 18, 1985. A second hazard ranking was conducted in response to public comments, producing a score of 34.68 in January 1990. On February 21, 1990, the H.O.D. Landfill site was listed in the NPL.

Waste Management of Illinois, Inc. (WMI) retained Warzyn Inc. (Warzyn) to perform the Remedial Investigation (RI) for the site and its associated work plan. Sampling of the site was conducted in accordance with work plans prepared by Warzyn and WMI, and approved by USEPA Region V, in May-July 1993 and March 1994. The 1993 sampling round focused on surface soil, surface water, groundwater, private wells, municipal wells, leachate and landfill gas. The 1994 sampling round focused on surface water, sediment, groundwater, and municipal wells. The results of the RI are described in Warzyn (1993) and will be further analyzed in the final RI report (not yet completed). ICF Kaiser Engineers (ICF KE) and the WEINBERG CONSULTING GROUP inc. (WEINBERG GROUP) were retained by WMI to perform the Baseline Risk Assessment (RA) for the H.O.D. Landfill Site. This report presents the findings of the Baseline RA which evaluated human and environmental health risks resulting from potential exposures to chemicals associated with the site. Exposure and risk estimates are based on the data collected during both RI sampling rounds.

The Baseline RA was conducted under Subpart E, Section 300.430(d) of the revised National Contingency Plan (NCP) as promulgated on March 8, 1990 (USEPA 1990). Paragraph (d)(4) of this section directs that a Baseline RA be conducted to characterize the current and potential future threats to public health and the environment that may be posed by contaminants migrating to groundwater, surface water or sediment, released to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain. The results of the Baseline RA are intended to assist in making risk management decisions concerning the necessity for remediation, the nature and extent of remediation, and selection of remedial alternatives.

In addition to following the 1990 NCP, this Baseline RA was conducted in accordance with more recent USEPA guidance on presumptive remedies for municipal landfill sites (USEPA 1993). The presumptive remedy approach streamlines the process of identifying the need for, and nature and extent of, landfill site remediation. It accomplishes this by establishing source containment as the presumptive remedy for municipal landfill sites, thereby obviating the need for a detailed risk assessment of the landfill source area. Through discussions with USEPA Region V, the presumptive remedy guidance was interpreted to mean that the H.O.D. Landfill Baseline RA need not evaluate potential risks to a hypothetical future on-site resident. Rather, the need for on-site remediation was assessed in the Baseline RA by comparing on-site groundwater concentrations to Safe Drinking Water Act Maximum Contaminant Levels (MCLs), MCL Goals (MCLGs), and available Illinois drinking water standards. Consistent with a more traditional approach, the Baseline RA also addressed potential human health and environmental impacts associated with the presence or possible migration of site-related chemicals from the landfill.

In general, this risk assessment follows relevant guidance and standards developed by the USEPA (1986a,b, 1989a,b, 1991, 1992a,b). This Baseline RA also is based on a Technical Work Plan for the H.O.D. Landfill Baseline Risk Assessment (ICFKE 1993, USEPA 1994a,b,c, WEINBERG 1994, WMII 1994) which was approved by USEPA Region V in June 1994. The inclusion of approaches and values specified by USEPA Region V, however, should not be construed to imply any independent verification or concurrence on the part of WMII, ICF KE, or the WEINBERG GROUP.

The Baseline Risk Assessment is organized as follows:

Section 2, Identification of Chemicals of Potential Concern. The chemicals detected in media investigated during the RI are identified and discussed. The RI data are summarized by presenting the frequency of detection and the range of detected concentrations in landfill-

related samples and in background samples. Based on an evaluation of the data and a comparison to background concentrations, chemicals of potential concern are selected for further evaluation.

Section 3, Toxicity Assessment. The methodology used to describe the potential toxicity of chemicals to humans and the range of toxic effects for each chemical of potential concern is presented. Chemical-specific toxicity criteria to be used in the quantitative risk assessment are presented.

Section 4, Human Exposure Assessment. The potential pathways by which human populations may be exposed to chemicals of potential concern are discussed and exposure pathways are selected for further evaluation. For each pathway selected for quantitative evaluation, the chemical concentrations at the point of potential exposure are estimated. Then the magnitude, frequency, and duration of exposure are estimated for each pathway and exposures are quantified.

Section 5, Risk Characterization. The general principles of the risk characterization process are described. For each exposure pathway selected for evaluation, quantitative risk estimates are developed by combining the estimated exposure values for potentially exposed populations with toxicity criteria.

Section 6, Ecological Risk Assessment. The potential risks to aquatic life and terrestrial animals and plants are evaluated. Potential exposure pathways for selected representative species are evaluated. Toxicity values along with estimated exposure point concentrations are used to characterize potential ecological risks associated with the site.

Section 7, Discussion of Uncertainties. This discussion focuses on the major sources of uncertainty affecting the health risk assessment: environmental parameter measurement, fate and transport modeling, estimation of exposure parameters and quantification of exposures, and toxicological data.

2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

This section of the Baseline Risk Assessment discusses the selection of chemicals of potential concern for detailed evaluation. The purpose of selecting chemicals of potential concern (COPCs) is to identify those chemicals present at the site most likely to be of concern to human health and the environment. Prior to selecting COPCs the first step is to summarize all available RI data. Both the summarization of data and the selection of COPCs are based on the discussions and methods presented in the Risk Assessment Workplan which was approved by USEPA Region V in June 1994. The only differences between the Workplan and the analysis presented in this section result from the incorporation of the March 1994 sampling data.

2.1 DATA SUMMARY

The Remedial Investigation (RI) data from both the May 1993 and March 1994 sampling rounds were summarized according to the following procedures, which are in accordance with USEPA (1989):

- Data were summarized by environmental medium and, as relevant, by subgroups within environmental media. Grouping data helps in determining exposure point concentrations for use in the Baseline Risk Assessment and in the identification of areas potentially requiring remediation. The data groupings are shown in Table 2-1. These groupings include sample data from groundwater (on- and off-site), leachate (on-site), landfill gas (on-site), surface soil (on-site), surface water (upstream and downstream), sediment (upstream and downstream), municipal wells (off-site) and private wells (off-site).
- A comparison of sample concentrations to field, trip and laboratory blanks was made by Warzyn according to USEPA (1989) guidance. Sample results were considered to be positive (detected) values if the concentration of the chemical in the site sample exceeded five times (uncommon sampling/laboratory contaminants) or ten times (typical sampling/laboratory contaminants acetone, methylene chloride, toluene, phthalates) the maximum amount detected in any associated blank. In accordance with USEPA (1989) guidance, chemicals detected at concentrations less than five or ten times the concentration in an associated blank were considered to be nondetects for data summary purposes, and these blank-related chemical concentrations were considered to be the detection limit for the chemical in that sample (i.e., the detected concentration was qualified with a U qualifier).

- The frequency of detection was calculated for each chemical as the ratio of the number of samples in which the chemical was detected to the number of samples analyzed for that chemical. Duplicate samples collected from the same sample location were not treated as independent samples.
- Duplicate samples from a given sampling location were averaged together to calculate the arithmetic mean concentration of each chemical at that sampling location.
- For samples in which a chemical was not detected, one-half of the chemical- and sample-specific detection limit was used to calculate summary statistics.
- To supplement the information provided in the data summary tables, arithmetic mean concentrations were calculated as the average across locations for each chemical in a given environmental medium and data group. In calculating mean concentrations, if one-half the detection limit for a non-detected chemical was greater than the maximum detected concentration in a data group, the non-detected result was excluded for that chemical. This was done to prevent the average from being artificially biased by high detection limits (USEPA 1989). The number of samples and the range of detection limits used to calculate the arithmetic means are included in the summary statistics tables. (The arithmetic means shown in these tables are, however, not used as exposure point concentrations.)

Tables 2-2 through 2-9 summarize the site sampling data from the RI. Table 2-10 summarizes the results from the field and trip blanks.

2.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Once all the data were summarized, they were screened to select COPCs for further evaluation in the Baseline RA. The methods used to select chemicals, described below, take into account the November 2, 1993 memorandum from Andrew Podowski, USEPA Region V, to Contractors regarding Identification of Chemicals of Concern at Superfund Sites. These methods were also presented in the Risk Assessment Workplan and approved in June 1994 by USEPA Region V.

It is important to recognize that the selection of a COPC does not necessarily indicate that it poses a problem or potential problem to human health or the environment. The selection of a chemical only indicates that there is a need to evaluate it in the Baseline RA to determine if it may result in potential

health risks. For the H.O.D. Landfill site, in particular, conservative methods were used to select chemicals because of the lack of site-specific background data and the small sample sizes in some data groupings, resulting in the selection of many chemicals which may not be site related.

The methodology described below was used to select COPCs.

- Data were screened to eliminate inorganic chemicals that are present at or below background levels. The Student's t-test was used to determine the site-relatedness of a chemical. Based on the results of this test, all inorganic chemicals in site sample data groups not significantly (statistically) elevated above background concentrations were eliminated as COPCs. A significance level of $p=0.05$ was used.
- The background groundwater data used in the t-tests were Lake County, Illinois groundwater data obtained from the Illinois State Water Survey (ISWS 1993) (shown in Table 2-11). These data were obtained at depths ranging from approximately 123 - 330 feet below land surface (BLS). The dissolved regional data were used in conjunction with the site monitoring well data, which were filtered prior to analysis for metals. The total metals regional data were used in conjunction with the municipal and private well data since these were not filtered prior to analysis. The comparison of the regional data to the deep sand and gravel aquifer data and to the surficial aquifer data should provide a reasonable indication of a chemical's site-relatedness. The regional background data was used since there were an insufficient number of site-specific background (upgradient) groundwater sample locations in the RI (see Table 2-1).
- The background soil data used in the t-tests were obtained from the U.S. Geological Survey (USGS) (Boerngen and Shacklette 1981) for Cook County, Illinois and Kenosha and Green Counties, Wisconsin. The available USGS data are summarized in Table 2-12.
- In some instances, inorganic chemicals were not included in the background information but were detected in the site data. In this situation the detected chemicals were automatically selected as COPCs, even though they may actually not be site-related.
- For some data groupings, fewer than three samples were available, and thus a statistical test of significance could not be performed. As directed by USEPA Region V as part of the Workplan for this site, in these instances detected chemicals were automatically selected as

COPCs. This may result in the selection of chemicals which are not actually site-related.

- Several of the inorganic chemicals detected in site samples are essential human nutrients not expected to pose risks at the reported concentrations. These chemicals (calcium, magnesium, potassium, sodium and iron) were not selected as COPCs.
- All organic chemicals were selected as COPCs. It should be noted that some of these may actually be sampling artifacts because some data groupings had few detections of a chemical at levels near to or below the Contract Required Detection Limits (CRDLs) (e.g., 2-methylphenol was detected in 1 of 4 private well samples at a concentration of 0.9 ug/L in comparison with a CRDL of 10 ug/L).

Tables 2-13 and 2-14 summarize the initial results of the chemical selection process for the groundwater, private well, municipal well, soil, surface water and sediment data. Highlighted cells in the tables indicate those chemicals which were selected as COPCs. The notations within each cell indicate the rationale for each chemical's selection or exclusion, according to the methods outlined above. All of the 19 organics detected in landfill gas were also selected as COPCs.

3.0 TOXICITY ASSESSMENT

The general methodology for the classification of health effects and the development of health effects criteria is described in Section 3.1 to provide the analytical framework for the characterization of human health risks in Section 5. In Section 3.2, the health effects criteria that will be used to derive estimates of risk are presented and the toxicity of the chemicals of potential concern is briefly discussed.

3.1 HEALTH EFFECTS CLASSIFICATION AND CRITERIA DEVELOPMENT

For risk assessment purposes, individual chemicals are separated into two categories of chemical toxicity depending on whether they exhibit principally noncarcinogenic or carcinogenic effects. This distinction relates to the currently held regulatory opinion that these two categories of chemicals differ with respect to whether or not thresholds exist for their toxic effects. For the purpose of assessing risks associated with potential carcinogens, USEPA has adopted the science policy position that a small number of molecular events can evoke changes in a single cell, or a small number of cells, that can lead to tumor formation. This is described as a non-threshold mechanism, because it is assumed that any non-zero exposure to a carcinogen poses some finite probability of causing cancer.

In the case of chemicals exhibiting noncarcinogenic effects, it is believed that cells have substantial functional redundancy and/or compensatory mechanisms that must be exceeded by some critical concentration (threshold) before the health effect is manifested. For example, an organ can have a large number of cells performing the same or similar functions that must be significantly depleted before the effect on the organ is measurable. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without appreciable risk of causing the disease.

3.1.1 Health Effects Criteria for Potential Carcinogens

For chemicals exhibiting carcinogenic effects, USEPA's Carcinogen Risk Assessment Verification Endeavor (CRAVE) has estimated upper-bound excess lifetime cancer risks associated with various levels of exposure to potential human carcinogens by developing chemical-specific cancer slope factors and/or unit risks. A cancer slope factor is expressed in terms of a reciprocal of dose, as units of (mg chemical/kg body weight-day)⁻¹. It describes the upper bound increase in an individual's risk

of developing cancer over a 70-year lifetime per unit of exposure. Unit risks are expressed as either a reciprocal air concentration in units of $(\mu\text{g}/\text{m}^3)^{-1}$, or as a reciprocal drinking water concentration, in units of $(\mu\text{g}/\text{L})^{-1}$. Similarly, they are defined as the probability of an individual developing cancer over a 70-year lifetime per unit of concentration. Because regulatory efforts are generally focused toward protecting public health, including even the most sensitive members of the population, the cancer slope factors and unit risks are derived using conservative assumptions.

Slope factors and unit risks are derived from the results of human epidemiological studies or chronic animal bioassays. The animal studies usually must be conducted using a small number of animals and relatively high doses in order to detect possible adverse effects. Because humans are expected to be exposed to doses lower than those used in the animal studies, the data must be adjusted by using mathematical models. The data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response curve. In general, after the data are fit to the dose-response model, the 95th percent upper confidence limit of the slope of the resulting dose-response curve is calculated. This upper bound limit is subjected to various adjustments, and an interspecies scaling factor is applied to derive the slope factor or unit risk for humans. Thus, the actual human risks associated with exposure to a potential carcinogen quantitatively evaluated based on animal data are generally believed to be less than the risks estimated using these slope factors or unit risks; they may be as low as zero (USEPA 1986). Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an *ad hoc* basis. These models provide rough, but plausible, estimates of the upper limits on lifetime risk. Slope factors and unit risks based on human epidemiological data are also derived using very conservative assumptions and, as such, they too are believed to over-estimate risks. Therefore, while the actual risks associated with exposures to potential carcinogens are unlikely to be higher than the risks calculated using a slope factor or unit risk, they could be considerably lower.

When the upper bound cancer slope factor is multiplied by the lifetime average daily dose (LADD) of a potential carcinogen (in $\text{mg}/\text{kg}\cdot\text{day}$), or the unit risk is multiplied by the inhalation exposure concentration (IEC) of a potential carcinogen (in $\mu\text{g}/\text{m}^3$), the product is the upper bound excess lifetime individual cancer risk (or upper bound probability of contracting, not dying from, cancer) associated with exposure at that dose or air concentration. Upper bound means that the risk estimate is unlikely to be underestimated but it may very well be overestimated. This is because of the inherent conservativeness in the cancer slope factors and unit risks (i.e., they are upper bound estimates) and because exposure assumptions used in risk assessments (including this one) are also conservative.

An individual risk level of one in one million (1×10^{-6}), for example, represents an upper bound probability of 0.0001% that an individual may develop cancer over his or her lifetime as a result of lifetime exposure to a potential carcinogen. For context, the average American's background risk of developing cancer is approximately three in ten (i.e., 30% or 300,000-times higher than a one in one million risk level).

Besides the above numerical description of risk, USEPA also assigns weight-of-evidence classifications to potential carcinogens. Under this system, chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. The weight-of-evidence classification is an attempt to stratify chemicals as to our current scientific knowledge regarding their ability to cause cancer. The classification thus provides a descriptor for each chemical substance although it does not impact numerical potency. Three major factors are considered in characterizing the overall weight-of-evidence for carcinogenicity: (1) the quality of the evidence from human studies; (2) the quality of evidence from animal studies, which are combined into a characterization of the overall weight-of-evidence for human carcinogenicity; and then (3) other supportive information which is assessed to determine whether the overall weight-of-evidence should be modified. USEPA's final classification of the overall evidence has five categories:

Group A chemicals (human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer.

Groups B1 and B2 chemicals (probable human carcinogens) are agents for which there is limited (B1) or inadequate (B2) evidence of carcinogenicity from human studies. Group B2 agents also have sufficient evidence of carcinogenicity from animal studies.

Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals.

Group D chemicals (not classified as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available.

Group E chemicals (evidence of non-carcinogenicity in humans) are agents for which there is no evidence of carcinogenicity in adequate human or animal studies.

The cancer risks developed in this report are all accompanied by this weight-of-evidence classification. The reader should keep in mind that regardless of potency, there are important qualitative differences between chemicals which have been demonstrated to be human carcinogens and those chemicals for which the evidence is limited. For example, the risks estimated to be associated with exposures to Group A chemicals are characterized by less uncertainty than risks estimated for Group B2 chemicals.

3.1.2 Health Effects Criteria for Noncarcinogens

Health criteria for chemicals exhibiting noncarcinogenic effects are generally developed using verified risk reference doses (RfDs) and/or reference concentrations (RfCs). These are developed by USEPA's RfD/RfC Work Group and listed in the Integrated Risk Information System (IRIS) or can be obtained from USEPA's Health Effects Assessment Summary Table (HEAST). The RfD is expressed in units of dose (mg chemical/kg body weight-day), while the RfC is expressed in concentration units (mg chemical/m³ air or ug chemical/m³ air). RfDs and RfCs are usually derived either from human studies involving work-place exposures or from animal studies, and are adjusted using uncertainty factors. The RfD or RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD/RfC is used as a reference point for gauging the potential for non-carcinogenic effects to be induced in an exposed population.

Usually, exposures that are less than the RfD/RfC are not likely to be associated with adverse health effects. As the frequency and/or magnitude of the exposures exceeding the RfD/RfC increase, the likelihood that adverse effects in a human population increases. RfD/RfCs are developed for either chronic (lifetime) exposure and/or subchronic (less than seven years) exposure.

The RfDs/RfCs are derived using uncertainty factors which reflect scientific judgement regarding the adequacy of the data used to estimate the RfD/RfC. Uncertainty factors, generally 10-fold factors, are intended to account for:

- (1) the variation in sensitivity among members of the human population;
- (2) the uncertainty in extrapolating animal data to humans;
- (3) the uncertainty in extrapolating data obtained in a study that is less-than-lifetime exposure to lifetime exposure;
- (4) the uncertainty in using lowest-observable-adverse-effect level (LOAEL) data rather than no-observable-adverse-effect level (NOAEL) data; and
- (5) the inability of any single study to adequately address all possible adverse outcomes in humans.

When taken together, these uncertainty factors may confer a margin of safety of up to 10,000 to the experimentally obtained toxicity data. In some cases, modifying factors are also applied to RfDs/RfCs

to cover other uncertainties in the toxicity database and reflect the professional judgement of those reviewing the database. The net result is that RfDs/RfCs always bias risk estimates in the direction of overestimation.

3.2 HEALTH EFFECTS CRITERIA FOR THE CHEMICALS OF POTENTIAL CONCERN

Tables 3-1 and 3-2 present chronic oral and inhalation health effects criteria (slope factors/RfDs, and unit risks/RfCs), respectively, for the COPCs selected to be quantitatively evaluated in this assessment. The toxicity criteria were primarily obtained from USEPA's Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEASTs).

No quantitative oral health effects criteria were available from USEPA for aluminum, cobalt, and 2-hexanone and therefore, potential risks associated with oral exposures to these chemicals were not quantitatively evaluated. In addition, no quantitative inhalation health effects criteria have been developed by USEPA for the following organics: acetone, cis-1,2-dichloroethene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and xylenes. Therefore, potential risks associated with inhalation exposures to these chemicals were not quantitatively evaluated. Exclusion of the chemicals listed above from quantitative evaluation is not anticipated to result in significant underestimates of overall risk.

In some instances, quantitative oral health effects criteria for a surrogate chemical were used to represent chemicals for which toxicity criteria were not available. Oral toxicity criteria were unavailable for the following noncarcinogenic PAHs: dibenzofuran, 2-methylnaphthalene, naphthalene, and phenanthrene. These chemicals were conservatively assumed to have the same potential to cause adverse effects as pyrene, another noncarcinogenic PAH for which a toxicity criterion has been developed. For those carcinogenic PAHs lacking slope factors, benzo(a)anthracene, benzo(b)fluoranthene, and chrysene, the slope factor for benzo(a)pyrene was used together with a toxicity equivalency factor (TEF) to evaluate carcinogenic effects. These TEFs are presented in Section 4.

USEPA has not developed an RfD or RfC for lead. For this assessment, lead concentrations in water will be compared to the USEPA action level of 15 ug/L. USEPA also considers a final cleanup level of 15 ug/L for lead in groundwater to be protective for drinking water given a 15 ug/L level in drinking

water would correlate with blood lead levels below 10 ug/dL in roughly 99 percent of young children who are not exposed to excessive lead paint hazards or heavily contaminated soils (USEPA 1990).

Dermal exposures to carcinogenic PAHs are evaluated using a different methodology because they are contact carcinogens. Dermal exposures to carcinogenic PAHs and coal tar (which include PAHs) have been associated with adverse effects to the skin, ranging from localized irritation to skin cancer. To date, the USEPA has not developed a methodology for evaluating the potential effects on the skin from dermal contact with carcinogenic PAHs. Experimental skin painting studies have been conducted, however, on animals and the results of these experiments can be used to evaluate the possibility of adverse skin cancer effects. Table 3-3 summarizes seven experimental studies identified from the Agency of Toxic Substances and Disease Registry (ATSDR 1990) and other review sources that were used for this purpose in this assessment as a screening-level analysis. In this table, the experimentally applied doses of PAHs are shown along with the incidence of skin tumors among the tested animal populations. The applied doses are presented in units of ug/cm² exposed skin or ug/cm²-day. The tumor incidences are presented as the percent of the tested animal population showing tumor development. It should be noted that one of these studies, LaVoie et al. (1982) is an initiation-promotion study, in which tumors developed following the application of PAHs and a tumor promoter. This study indicates the concentrations of PAHs which can interact with other tumor-promoting chemicals that may be present at the site to induce tumors. For example, based on the information shown in Table 3-3, dermal exposures of benzo(b)fluoranthene of 10-100 ug/cm² skin might increase an individual's risk of developing skin cancer. These values will be used as points of comparison in the risk assessment (Section 5).

4.0 HUMAN EXPOSURE ASSESSMENT

The purpose of this section is to calculate the frequency, duration, and magnitude of exposures which could occur to individuals in the H.O.D. Landfill area. As part of this evaluation, information on the exposure setting and the potentially exposed populations is presented (Section 4.1). This is followed by a discussion of potential exposure pathways through which populations could be exposed to chemicals at or originating from the site (Section 4.2). For each pathway selected for quantitative evaluation, the chemical concentrations at the points of exposure are estimated (Section 4.3), followed by a calculation of potential chemical intakes (Section 4.4).

4.1 SITE CHARACTERIZATION

The H.O.D. Landfill occupies approximately 80 acres of land (51 of which have been used for disposal) located within the eastern boundary of the Village of Antioch in Lake County, Illinois. The layout of the site is shown in Figures 1-1 and 1-2. The landfilled area actually consists of two separate landfill areas (the "old" landfill and the "new" landfill) although it is visually continuous. The "old" landfill consists of 24.2 acres located on the western third of the property while the "new" landfill comprises 26.8 acres located immediately east of the "old" landfill.

The area surrounding the H.O.D. Landfill site is a mixture of agricultural areas and fields, with some industrial and residential areas. Sequoit Creek runs along the southern and western boundary of the site. The Silver Lake residential subdivision is located east of the site, and agricultural land, scattered residential areas, and undeveloped land is located to the north of the site. South of the site, a large wetland area extends from Sequoit Creek and a lake, Silver lake, is located approximately 200 feet southeast of the site. The Sequoit Acres Industrial Park, which is constructed on former landfill and fill areas, is located west of the site and borders Sequoit Creek. These surrounding areas to the H.O.D. Landfill area also shown in Figure 1-1.

The nearest human receptors to the site are those residents living in nearby houses. Trespassers (e.g., local residents) could potentially access the site since it is not fenced; therefore, they are considered to be the primary human receptors for potential exposure to site-related chemicals under current land-use conditions. In identifying exposure pathways for detailed evaluation, those considered to be the most representative and most likely to occur were selected.

4.2 POTENTIAL EXPOSURE PATHWAYS

An exposure pathway describes the course a chemical takes from the source to the exposed individual. It is defined by four elements:

- a source and mechanism of chemical release to the environment;
- an environmental transport medium (e.g., soil, air) for the released chemical;
- a point of potential contact with the contaminated medium (referred to as the exposure point); and
- an exposure route (e.g., ingestion, inhalation) at the contact point.

An exposure pathway is considered complete only if all these elements are present. In a risk assessment, *only complete exposure pathways are evaluated. In this section, potential exposure pathways to individuals in the H.O.D. Landfill area are identified.*

In this assessment, only current land use conditions associated with the site as it exists today were evaluated. As discussed in Section 1, potential future risks to a hypothetical, on-site resident were not evaluated in accordance with USEPA's Presumptive Remedy for CERCLA Municipal Landfill Sites.¹ Rather, on-site groundwater concentrations were compared with MCLGs, MCLs, and Illinois drinking water standards. This analysis is presented in Section 4.5.

4.2.1 Potential Exposure Pathways Under Current Land Use Conditions

There are several pathways through which individuals could be exposed to site-related chemicals originating from the H.O.D. Landfill under current land-use conditions. Table 4-1 summarizes this exposure pathway analysis, indicating the exposure medium, release mechanism, exposure point, potential receptor and route of exposure. This table also indicates whether each pathway is potentially complete, and identifies those pathways that were quantitatively evaluated in the Baseline RA.

¹February 3, 1994 conference call between USEPA Region V, Waste Management of Illinois, Inc., the WEINBERG CONSULTING GROUP Inc., and ICF Kaiser Engineers.

4.2.1.1 Air Pathways

Individuals trespassing on the H.O.D. Landfill or those residents living near the site could potentially be exposed via inhalation of chemicals in the form of organic vapors emitted from the landfill surface or from surface water in Sequoit Creek, or as dust resulting from wind entrainment of surface soil. Inhalation of dust is not considered to be a likely exposure pathway because the surface of the landfill site is very well vegetated. However, as can be seen in the summarized soil data and landfill gas data in Section 2.0, volatile organic chemicals are present in landfill soil and landfill gas. Therefore, inhalation of volatile chemicals released from the landfill is a potential pathway and was evaluated for nearby residents. It was assumed that the nearby residents live essentially adjacent to the landfill and that their exposures will be long-term (i.e., a 30 year residence time). Since the resident's exposure would be higher than the short-term exposure that a trespasser would experience, inhalation exposures to ambient VOCs by trespassers were not evaluated.

4.2.1.2 Soil Pathways

The summarized soil data presented in Section 2.0 indicate that chemicals are present in on-site surface soils. Current site trespassers may contact surface soils resulting in direct dermal absorption and incidental ingestion. As discussed in Section 4.1 above, the likelihood and magnitude of potential exposures would be greater for trespassers than for other receptors (e.g., workers) at the landfill. Therefore, only site trespassers were evaluated.

4.2.1.3 Surface Water and Sediment Pathways

There is a potential for site trespassers to contact surface water and sediment in Sequoit Creek. Surface water in Sequoit Creek is shallow and intermittent and would therefore not be suitable for swimming, thus incidental ingestion of surface water is not a viable pathway. However, on-site trespassers may contact surface water and sediment while wading in Sequoit Creek, potentially resulting in dermal absorption of chemicals which have migrated from the landfill in surface water run-off. Trespassers could potentially ingest sediment during these activities as well. Because these exposures are much more likely to be experienced by trespassers, only this receptor population was evaluated.

4.2.1.4 Fish Pathway

Sequoit Creek is not known to be used for fishing, thus ingestion of fish was not evaluated.

4.2.1.5 Groundwater Pathways

The summarized data in Section 2 indicates that site-related chemicals may have been detected in on-site and off-site groundwater in the surficial aquifer and in the deep sand and gravel aquifer. There are no currently active residential wells on site, although there are some nearby residential wells screened in the deep aquifer. In addition, municipal wells for the Village of Antioch were also sampled. *Exposures to selected chemicals of concern in private wells, municipal wells, and off-site groundwater monitoring wells via ingestion, inhalation of VOCs while showering, and dermal absorption while showering were evaluated. VOCs were not detected in private wells nor in surficial sand groundwater, therefore the inhalation while showering pathway was not considered for these groundwater groupings.*

4.2.1.6 Summary of Current Use Pathways

In summary, the exposure pathways evaluated under current site and surrounding land use conditions are as follows:

- Incidental ingestion of on-site surface soil by trespassers on the site;
- Dermal absorption of chemicals in on-site surface soil by trespassers on the site;
- Dermal absorption of chemicals in Sequoit Creek surface water by trespassers on the site;
- Incidental ingestion of Sequoit Creek sediment by trespassers on the site;
- Dermal absorption of chemicals in Sequoit Creek sediment by trespassers on the site;
- Groundwater ingestion from public supply wells by nearby adult residents;
- Groundwater ingestion from private wells by nearby adult residents;
- Groundwater ingestion from off-site groundwater monitoring wells by nearby adult residents (surficial sand and the deep sand and gravel aquifers);
- Inhalation of volatile organic chemicals while showering with groundwater from public supply wells by nearby adult residents;

- Inhalation of volatile organic chemicals while showering with groundwater from the off-site deep sand and gravel aquifer by nearby adult residents;
- Dermal absorption while showering with groundwater from public supply wells by nearby adult residents;
- Dermal absorption while showering with groundwater from private wells by nearby adult residents;
- Dermal absorption while showering with off-site groundwater (surficial sand and the deep sand and gravel aquifer) by nearby adult residents;
- Inhalation of volatile organic chemicals emitted from the landfill surface by nearby residents.

4.3 QUANTIFICATION OF EXPOSURE POINT CONCENTRATIONS

In order to calculate the magnitude of exposures and thus the risks which may be experienced by an individual in the site area, the concentration of the chemicals of potential concern in the various exposure media must be measured or estimated. These concentrations are referred to as exposure point concentrations. To estimate exposures, each concentration is combined with assumptions on the rate and magnitude of human contact with that medium. In general, exposure point concentrations for each pathway were determined using the RI data where available. For the residential showering scenario, shower air concentrations were estimated using a mathematical model (Foster and Chrostowski 1987). For the landfill gas inhalation pathway, air concentrations were estimated using an emissions model (Karimi et al. 1987) coupled with a screening-level box model. The following discussion presents information on concentrations calculated from both the RI data and using appropriate models.

The approach used to estimate exposure point concentrations follows that recommended in USEPA's Risk Assessment Guidance for Superfund (USEPA 1989a). The guidance recommends using the 95% upper confidence limit (UCL) on the mean concentration for the exposure point concentration. The methodology for calculating this statistic is discussed by Gilbert (1987) and Land (1975).

Most chemicals are log-normally distributed in the environment (Dean 1981, Ott 1988). The 95% UCL derived from a log-normal distribution is statistically unstable, especially when the sample size is small. Examination of the RI data revealed many instances when the calculated 95% UCL exceeded the maximum detected concentration due to small sample sizes. When the 95% UCL exceeds the

maximum measured value, USEPA (1989a) specifies that the maximum measured value be defaulted to for the exposure point concentration. This procedure was followed, but using the maximum detected value will likely result in an overestimation of risks associated with the site.

The following text summarizes the basis for the exposure point concentrations for each pathway. In cases where modeling was conducted to estimate these concentrations, a description is also provided.

4.3.1 Exposure Point Concentrations Under Current Land Use Conditions

4.3.1.1 Concentrations in Soil

The concentrations of chemicals of potential concern in on-site surface soils at H.O.D. Landfill are assumed to represent concentrations of chemicals to which landfill trespassers may be exposed. The exposure point concentration for each chemical of potential concern in on-site surface soil at the H.O.D. Landfill is shown in relevant tables in Section 4.4 (Quantification of Exposure). For each chemical of potential concern identified in surface soil, except 4,4-DDD and beryllium where the 95% UCL was used, the selected exposure point concentration used for the soil exposure pathways was the maximum detected concentration.

4.3.1.2 Concentrations in Surface Water and Sediment

Under current use conditions, young trespassing residents who live nearby are assumed to contact Sequoit Creek surface water and sediment at the H.O.D. Landfill. Concentrations measured in downstream sampled areas in these two media were considered to reflect surface water and sediment levels to which these receptors may be exposed. The exposure point concentration for each chemical of concern identified in surface water or sediment at the H.O.D. Landfill is shown later in relevant tables in Section 4.4 (Quantification of Exposure). Exposure point concentrations for all chemicals of potential concern in sediment were the maximum detected concentrations. The exposure point concentrations in surface water were the maximum detected concentrations for all chemicals except antimony where the calculated 95% UCL was used as the exposure point concentration.

4.3.1.3 Concentrations in Groundwater

As discussed previously, active private wells and public supply wells are currently located in the vicinity of the H.O.D. Landfill. Therefore exposure to chemicals of potential concern via ingestion of drinking water was considered a complete pathway under current site and surrounding land use conditions. Exposures were estimated for chemicals of potential concern in private wells, public supply wells, and in the off-site groundwater monitoring well data (surficial sand aquifer and deep sand and gravel aquifer). The maximum detected concentrations were used as the exposure point concentrations for all chemicals in the private well, off-site surficial sand aquifer and off-site deep sand and gravel aquifer groupings. For the public supply well grouping, the maximum detected concentrations were used as the exposure point concentrations with the exception of 1,2-dichloroethane and carbon disulfide where the calculated 95% UCL was used. The exposure point concentrations for the groundwater groupings are shown in the relevant tables in Section 4.4 (Quantification of Exposure).

4.3.1.4 Concentrations in Indoor Air While Showering

Indoor air volatile organic concentrations associated with showering were estimated using a model developed by Foster and Chrostowski (1987). This model was approved for use in this RA by USEPA Region V as part of the Technical Work Plan for the Baseline Risk Assessment.

The indoor air concentrations associated with exposure point concentrations of volatile organic chemicals identified in groundwater were calculated using this model for the selected VOCs in public supply wells and the off-site deep sand and gravel aquifer monitoring wells.² The input parameters used in the shower model are provided in Appendix A. The resulting shower room air concentration for each volatile organic chemical of concern is shown in relevant tables in Section 4.4 (Quantification of Exposure).

4.3.1.5 Concentrations in Air from Landfill Emissions

Chemical concentrations in ambient air resulting from landfill gas emissions were also modeled. First chemical emission rates (flux rates) from the landfill surface were predicted using a model provided by

²No VOCs were selected as chemicals of potential concern in private wells.

Karimi et al. (1987). In conjunction with the measured landfill gas concentrations. The flux rates were then combined with a screening level box model (Pasquill 1975) to predict air concentrations in the immediate vicinity of the landfill site. Appendix B provides a brief description of these modeling methods. The resulting air concentration for each selected volatile organic compound found in the landfill gas samples is shown in relevant tables in Section 4.4 (Quantification of Exposure).

4.4 QUANTIFICATION OF EXPOSURE

Exposures are estimated by combining environmental concentrations at the selected exposure points with information describing the extent, frequency, and duration of exposure for each receptor of concern. This section presents an overview of the approaches used to quantify exposures, followed by specific details for each selected exposure pathway. The approaches used in this section to quantify exposures are consistent with guidance produced by USEPA (1986a,b, 1989a, 1992a,b) and the H.O.D. Landfill Technical Work Plan for the Baseline Risk Assessment. The equations used to quantify exposures are presented in Appendix C.

For the ingestion and dermal absorption exposure pathways, exposures were quantified by an average daily dose, expressed in units of mg chemical/kg body weight-day (mg/kg-day). Dose can be defined as an exposure rate to a chemical determined over an exposure period per unit body weight, and it is calculated similarly for both ingestion and dermal pathways. There are, however, significant differences in the meaning and terms used to describe dose for the ingestion and dermal pathways. For the oral pathways of exposure, the doses calculated in this assessment are referred to as "potential doses." *The potential dose is the amount of chemical ingested and available for uptake in the body, and is analogous to the administered dose in a dose-response toxicity experiment.* For the dermal absorption pathways, the estimated dose is referred to as an "internal dose," and it reflects the amount of chemical that has been absorbed into the body and is available for interaction with biologically important tissues (USEPA 1992a).

Average daily doses are estimated differently for chemicals exhibiting noncarcinogenic effects and those exhibiting carcinogenic effects. Average daily doses for noncarcinogens are averaged over the duration of exposure, and following USEPA (1992a) guidance, are given the acronym ADDs (for average daily doses). For carcinogens, average daily doses are averaged over a lifetime, and are given the acronym LADDs (for lifetime average daily doses).

For the inhalation exposure pathways, chemical doses were not calculated due to the fact that the inhalation toxicity criteria are expressed in units of concentration [mg/m^3 for noncarcinogens and $(\text{ug}/\text{m}^3)^{-1}$ for carcinogens] rather than dose. Exposures via inhalation were assessed by comparing the air concentrations to which receptors are exposed, termed inhalation exposure concentrations (IECs), to toxicity criteria. The IECs used in this assessment were derived from the exposure point concentrations estimated in air (i.e., concentrations of volatile organic chemicals in a shower room) using modifying factors to incorporate pathway-specific information about exposures by receptors. These modifying factors were applied to the exposure point concentrations to account for differences in the H.O.D. Landfill exposure scenarios relative to that assumed by USEPA in deriving the inhalation toxicity criteria. As USEPA assumes constant exposure over a lifetime (carcinogens) or over the entire exposure duration (noncarcinogens) in developing toxicity criteria, the adjustments made to the exposure point concentrations pertain to exposure time (hours/day vs. 24 hours/day), exposure frequency (days/year vs. 365 days/year), and exposure duration (years vs. 70 years, for carcinogens only). Information on individual ventilation rate and body weight is not taken into account when deriving IECs. This adds uncertainty to the risk estimates for the inhalation pathways.

The average daily doses (ADDs or LADDs) and IECs are estimated using exposure point concentrations of chemicals together with other exposure parameters that specifically describe the exposure pathway. Based on USEPA risk assessment guidance (USEPA 1989a, 1991), exposures were quantified by estimating the reasonable maximum exposure (RME) associated with the pathway of concern. The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA 1989a). In terms of USEPA's exposure assessment guidance (USEPA 1992a), the RME risk estimates can be termed as high-end risk descriptors, using the reasonable worst case. The RME is intended to place a conservative upper bound on the potential risks, meaning that the risk estimate is unlikely to be underestimated but it may very well be overestimated. The likelihood that this RME scenario may actually occur is small, due to the combination of conservative assumptions incorporated into the scenario. The RME for a given pathway is derived by combining the selected exposure point concentration (based on the 95% upper confidence limit (UCL) on the mean concentration or maximum detected concentration) of each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA 1989a).

For the ingestion of soil or sediment by a site trespasser, the exposure point concentrations of carcinogenic PAHs were converted to benzo(a)pyrene equivalent concentrations. This was done in order to evaluate the potential risks associated with exposure to carcinogenic PAHs which lack an oral

cancer slope factor (USEPA 1993a). Under this approach, each carcinogenic PAH is characterized by its average toxic potency relative to that of benzo(a)pyrene. This relative potency is defined as the toxic equivalency factor (TEF). The significance of exposure to each carcinogenic PAH is evaluated by multiplying the concentration of the PAH by its respective TEF to derive a concentration in benzo(a)pyrene equivalents. The TEFs for carcinogenic PAHs were incorporated into the LADD equation for ingestion of soil and sediment, as shown in Appendix B.

As was discussed in Section 3, USEPA has not developed health effects criteria for lead. Therefore risks associated with lead exposure were not evaluated by deriving ADDs and combining this with a toxicity criterion. In this assessment, lead was selected as a chemical of potential concern only in surface water. Although incidental ingestion of surface water is not a selected pathway, the potential significance of lead in surface water will be evaluated by comparing the exposure point concentration of lead to a drinking water action level of 15 ug/L in Section 5 (Risk Characterization).

4.4.1 Average Daily Doses Under Current Land Use Conditions

Under current land use conditions, exposures associated with incidental ingestion and dermal contact with surface soil, dermal absorption of chemicals in sediment and surface water, ingestion of groundwater, inhalation of volatile chemicals and dermal absorption of chemicals while showering with groundwater, and inhalation of volatile chemicals from the landfill surface were assessed. The assumptions associated with calculating these exposures are detailed below and the equations used to estimate chemical doses (ADDs and LADDs) and IECs for each pathway are presented in Appendix C.

4.4.1.1 Incidental Ingestion of Surface Soil by Site Trespassers

This scenario evaluated potential exposures through incidental ingestion of COPCs in on-site surface soils by trespassers who may occasionally visit the landfill. Children and teenagers from 6-16 years of age were selected as the receptors to be evaluated in this assessment. The child/teenager is likely to incidentally ingest more soil per event and have a lower body weight than an adult, and thus the trespasser risks will likely be higher than those for an occasional site worker. The assumptions used to estimate doses to landfill trespassers are listed in Table 4-2 and are briefly described below. Appendix C presents the equations used to calculate ADDs and LADDs for the soil ingestion pathway.

The frequency of exposure estimate of 43 days/year was derived by considering site-specific climatic conditions. It was assumed that during winter months the frozen ground, snow cover, and/or heavy clothing worn by individuals would limit the period during which exposure through incidental ingestion may occur. Therefore, it was assumed that under RME conditions, trespassers would visit the landfill 1 day/week during the 300 days/year when maximum air temperatures are above freezing (NOAA 1989). A duration of exposure of 10 years was based on the age range of children and teenagers expected to visit the site (6 to 16 years of age). For exposures to child/teenage trespassers, an age-weighted average daily soil ingestion rate of 110 mg/day was used, based on values specified by USEPA (1991, 1989a). The value of 110 mg/day is based on information regarding soil ingestion by 6 to 16 year old children and was estimated assuming a daily ingestion rate of 200 mg/kg for 1 year and 100 mg/kg for 9 years. The fraction ingested variable accounts for the amount of total incidental soil ingested daily that is assumed to come from the H.O.D. Landfill. It was assumed that children and teenagers play on the landfill 4 hours/day, while they may be potentially exposed to soil during all waking hours (16 hours/day) (based on Calabrese et al. 1989). Thus, the fraction of the daily amount of soil ingested that was assumed to be from the landfill was 0.25 (4 hours/16 hours).

The body weight value of 40 kg for children and teenagers was based on data provided in USEPA (1989b). For potential carcinogens, the averaging time is based on a lifetime of 70 years (25,550 days) as recommended in USEPA (1991, 1989a). For noncarcinogens, the averaging time is equal to the exposure duration of 10 years (3,650 days).

Ingested chemicals present in a soil matrix may not be as readily available for absorption through the gastrointestinal tract due to their affinity for soil particles as chemicals ingested in a solution or diet (i.e., the matrices usually administered in experimental studies from which cancer slope factors and RfDs are derived). To account for the differences in bioavailability expected between the ingestion of a chemical adsorbed onto soil in comparison with typical toxicological animal study conditions, a relative oral bioavailability factor can be included in the dose calculations.

Insufficient data are available to derive relative oral bioavailability factors for the organic chemicals of potential concern and aluminum. Therefore, a relative oral bioavailability factor of 1.0 (a default value) was assumed for these chemicals. This conservative assumption means that there is no difference in absorption between chemicals incorporated in a soil matrix and in the vehicle used in the animal study from which the oral toxicity criteria were derived. For the remaining inorganic chemicals of potential concern, the relative oral bioavailability factors listed in Table 4-3 were used.

As was discussed in Section 4.4, a toxic equivalency factor (TEF) was applied to the exposure point concentrations of carcinogenic PAHs for which no cancer slope factors have been developed. A TEF was applied to the concentration of benzo(a)fluoranthene within the LADD equation to describe the relative carcinogenic potential of this PAH with respect to benzo(a)pyrene. The TEF is presented in Table 4-4.

The LADDs for chemicals exhibiting carcinogenic effects and the ADDs for chemicals exhibiting noncarcinogenic effects associated with the ingestion of surface soils by child/teenager trespassers at the H.O.D. Landfill site are summarized in Table 4-4.

4.4.1.2 Dermal Absorption of Chemicals from Surface Soils

This scenario evaluates potential exposures through dermal contact with chemicals of potential concern in on-site surface soil by child/teenager trespassers at the landfill. In general, the parameters describing frequency and duration of exposure, body weight and averaging time were identical to those used for estimating incidental ingestion of soil by trespassers and are presented in Table 4-2. Additionally, the exposure point concentrations used in the dermal absorption pathway are the same as those used for the soil ingestion pathways. Appendix C presents the equation used to calculate ADDs and LADDs for the soil dermal absorption pathway.

Parameters that are specific to the dermal exposure scenarios include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. The uncertainty contained in these parameters is large and necessitates the use of approximations (McLaughlin 1984).

For child/teenager trespassers, it was assumed that the hands, arms and legs would be exposed to landfill surface soil. Using data from USEPA (1985), and averaging across gender and age, it was estimated that the exposed skin surface area for child/teenage trespassers would be 6,000 cm². A soil-to-skin adherence factor of 1.0 mg/cm²-event was assumed, the reasonable upper default value provided in USEPA (1992b).

The amount of chemical in contacted soil absorbed through the skin into the body is needed to estimate dermal exposures. However, intensive investigation into the amount of chemicals that may be absorbed through the skin under conditions normally encountered in the environment (and

assumed to occur for this assessment) are lacking. While a number of approaches have been developed to estimate exposures to compounds in a soil matrix, the parameters in these approaches have not been well characterized (USEPA 1992b). For the purposes of this assessment, the dose resulting from contact with soil is evaluated by estimating the percent or fraction of the applied dose absorbed for the selected chemicals of potential concern. For a chemical to be absorbed through the skin from soil, it must be released from the soil matrix, pass through the stratum corneum, the epidermis and to the dermis wherein it encounters the systemic circulation. This series of events is dependent on a number of factors including the characteristics of the chemical itself, the concentration in the applied dose, the site of exposure, inter-individual variability, and characteristics of soil (e.g., particle size and organic content). Because of the paucity of experimental data on dermal absorption from soil, not all of these parameters can be taken into account in estimating dermal absorption percentages.

In general, compounds that are both water soluble and have a strong tendency to partition into oils will display relatively high permeation rates through skin (Michaels et al. 1975). In addition, dermal absorption from exposure to solvents or solutions is likely to differ from that associated with exposure to a soil matrix. This can be taken into account by multiplying the fraction absorbed from the experimental study by the ratio of the percent of applied dose absorbed through the skin into circulation from a soil matrix divided by its percent absorption from a solvent matrix (e.g., acetone, methanol).

In performing this risk assessment, chemical-specific dermal absorption percentages based on experimental data were used where available, and where appropriate, an adjustment to account for the soil matrix was made. Where experimental data are not available, absorption percentages were assumed based on analogy to other similar chemicals and/or conservative default values. The dermal absorption percentages used for dermal contact with soil are shown in Table 4-5. (This table also includes the selected chemicals for sediment.) Except for thallium (a COPC for sediment), metals present in inorganic (rather than organometallic) forms are poorly absorbed through intact skin during exposures of short duration (e.g., Moore et al. 1980, Skog and Wahlberg 1964, Wahlberg 1968a,b, Lang and Kunze 1948). Exposure via dermal absorption from contacted soil is expected to be insignificant for these metals, therefore doses via dermal absorption were not calculated for aluminum, beryllium, cadmium, and chromium in soil.

The LADDs for chemicals exhibiting carcinogenic effects and the ADDs for chemicals exhibiting noncarcinogenic effects associated with the dermal absorption of chemicals from surface soils at the H.O.D. Landfill are summarized in Table 4-6 for child/teenager trespassers.

The potential skin cancer risks associated with dermal contact with carcinogenic PAHs in surface soil were estimated differently than for other carcinogenic chemicals. There is no laboratory epidemiologic evidence that PAHs cause internal cancers following dermal absorption (IARC 1984). However, carcinogenic PAHs are well known to cause skin cancer upon direct contact (LaVoie et al. 1982, Bingham and Falk 1969, Wislocki et al. 1977, Levin et al. 1976, 1977, Habs et al. 1980). Therefore, direct contact with carcinogenic PAHs may be of concern. Dermal exposure to carcinogenic PAHs in units of ug/cm²-day exposed skin were estimated using the equation presented below:

$$DER = (Cs)(Bio)(Acc)/10^6$$

where:

DER	=	dermal exposure (ug/cm ² -day),
Cs	=	soil concentration (ug/kg),
Bio	=	bioavailability factor to adjust for soil matrix effect (unitless, equals 1 if no effect of soil or sediment matrix is assumed),
Acc	=	soil-to-skin adherence factor (mg/cm ² -day)
10 ⁶	=	conversion factor (10 ⁶ mg/kg).

Dermal exposures were also calculated in units of ug/cm² by multiplying the dermal exposures in ug/cm²-day by the total number of days per year the individual is assumed to be exposed. This conversion is necessary because certain experimental studies compare chemical concentrations in units of ug/cm²-day to elevated skin cancer incidence (Habs et al. 1980). These exposures will be compared to experimental data in units of ug/cm² and units of ug/cm²-day associated with elevated skin cancer incidence. A soil-to-skin adherence factor of 1.0 mg/cm²-day for soil was used for child/teenager trespassers. The amount of CPAHs bioavailable from contacted soil is expected to be less than from an aqueous or solvent matrix; however, it was conservatively assumed that all of the CPAHs in soil were as bioavailable as from these matrices, therefore a bioavailability factor of 1 was assumed. Potential skin cancer risks associated with contact of PAHs in soil will be presented in Section 5 (Risk Characterization).

4.4.1.4 Dermal Absorption of Chemicals from Surface Water

Direct contact with chemicals of potential concern in surface water by child/teenage trespassers playing in Sequoit Creek was considered in this assessment. The 6 to 16 age group was selected as children and teenagers are most likely to contact surface water as a result of play or other activities. The exposure parameters selected to evaluate chemical doses to children and teenagers contacting surface water are listed in Table 4-7 and are described briefly below.

Children and teenagers were assumed to play or wade in surface water bodies 1 hour/day for 2 days/week during the four months, June through September, when the average daily maximum temperatures are above 70° F (NOAA 1989). This results in an exposure frequency of 35 days/year. The assumption of 1 event/day assumes that the exposed skin of children or teenagers remains wet for the entire time period that they are assumed to play or wade in the water bodies. Duration of exposure was based on the age range of children and teenagers expected to visit Sequoit Creek (6 to 16 years of age). The body weight value of 40 kg for children and teenagers was based on data provided in USEPA (1989a) and the averaging time based on a lifetime estimate of 70 years (25,550 days). For noncarcinogens, the averaging time is equal to the exposure duration of 10 years (3,650 days).

Estimation of chemical dose via dermal absorption from water requires an estimation of skin surface area exposed, the permeability coefficient for the chemical from water through the skin, and exposure time. For this assessment, it was assumed that the hands, legs and feet of the children and teenagers would be exposed to surface water during wading. Using data provided by USEPA (1985), and averaging across gender and age, it was estimated that the average skin surface area exposed to surface water while wading would be 5,300 cm².

A permeability coefficient is defined as a flux value, normalized for concentration, that represents the rate at which a chemical penetrates the skin (in units of cm/hr). Experimental or measured permeability coefficients provided in USEPA (1992b) were used for the chemicals of potential concern if available. In the absence of measured values for organics, permeability coefficients estimated by USEPA (1992b) using the following equation were employed:

$$\log(\text{Permeability Coefficient}) = -2.72 + (0.71 * \log K_{ow}) - (0.0061 * MW)$$

Inorganics without measured permeability coefficients were assumed to have permeability coefficients of 10^{-3} cm/hr, the default value provided in USEPA (1992b). Permeability coefficients of the chemicals of potential concern in surface water identified in this assessment are presented in Table 4-8.

The equations used to derive the ADDs and LADDs associated with dermal absorption of chemicals from surface water are presented in Appendix C. LADDs for chemicals exhibiting carcinogenic effects and ADDs for chemicals exhibiting noncarcinogenic effects due to direct contact with surface water by nearby child and teenager trespassers are summarized in Table 4-9.

4.4.1.5 Incidental Ingestion of Sediment

Potential exposures through incidental ingestion of sediment were also estimated for site trespassers. Again, children and teenagers from 6-16 years of age were selected as the receptors to be evaluated for this pathway, as this age group is the most likely to contact sediment through play or other activities. The assumptions used to estimate chemical doses to children and teenagers contacting sediment are listed in Table 4-10 and are briefly described below. Appendix C presents the equation used to calculate ADDs and LADDs for this pathway.

As for the surface water contact pathway, the frequency of exposure estimates for sediment contact were based on site-specific climatic conditions. It was assumed that children and teenagers would play in or visit Sequoit Creek 2 days/week from June through September, the four months when the average daily maximum air temperatures are above 70°F (NOAA 1989). Duration of exposure was based on the age range of children and teenagers expected to visit the creek (6 to 16 years of age). The sediment ingestion rates and fraction ingested variable for this pathway were derived as described for the soil ingestion pathway. An age-weighted average daily sediment ingestion rate of 110 mg/day was used, based on values specified by USEPA (1991, 1989a) for soil ingestion and assuming a daily ingestion rate of 200 mg/kg for 1 year and 100 mg/kg for 9 years. It was assumed that children and teenagers would contact sediment in the creek 1 hour/day, therefore the fraction ingested variable (accounting for the amount of sediment ingested daily that is assumed to come from downstream of the site) was estimated to be 0.06 (1 hour/16 waking hours). The body weight value of 40 kg for children and teenagers was based on data provided in USEPA (1989a) and the averaging

time is based on a lifetime estimate of 70 years (25,550) days as recommended in USEPA (1991, 1989a). For noncarcinogens, the averaging time is equal to the exposure duration (3,650 days).

As described for soil, ingested chemicals present in an environmental matrix may not be as readily available for absorption through the gastrointestinal tract as chemicals ingested in a solution or diet (i.e., the matrices usually administered in experimental studies from which cancer slope factors and RfDs are derived). Insufficient data are available to derive relative oral bioavailability factors for the selected organic chemicals of potential concern. Therefore, a relative oral bioavailability factor of 1.0 (a default value) was assumed for these chemicals. This conservative assumption means that there is no difference in absorption between chemicals incorporated in a sediment matrix and in the vehicle used in the animal study from which the oral toxicity criteria were derived. For arsenic and thallium, the relative oral bioavailability factors listed in Table 4-3 were used.

As was described for soil, TEFs were applied to the LADD equations for the carcinogenic PAHs to describe the relative carcinogenic potential of these PAHs with respect to benzo(a)pyrene. These factors are presented in Table 4-11.

The LADDs for chemicals exhibiting carcinogenic effects and the ADDs for chemicals exhibiting noncarcinogenic effects associated with the incidental ingestion of sediment from the H.O.D. Landfill site by child/teenager trespassers are summarized in Table 4-11.

4.4.1.6 Dermal Absorption of Chemicals from Sediment

Potential exposures through dermal contact with chemicals of potential concern in sediment at the site were also evaluated. The receptors identified for this pathway were child and teenager trespassers since, as described previously, this age group is the most likely to contact sediment through play or other activities. The parameters for this pathway describing frequency and duration of exposure, body weight and lifetime were identical to those used for estimating dermal contact with surface water by child/teenager trespassers and are presented in Table 4-10. Appendix C presents the equation used to calculate ADDs and LADDs for this pathway.

Additional parameters needed to assess the dermal exposure scenario include the area of exposed skin, the amount of sediment adhering to the skin, and amount of chemical absorbed through the skin

from sediment. As described for dermal contact with soil, the uncertainty contained in these parameters is large and necessitates the use of approximations (McLaughlin 1984).

For child and teenager trespassers, it was assumed that the feet and hands would be exposed to sediment. Using data from USEPA (1985), and averaging across gender and age, it was estimated that the exposed skin surface area for child and teenager trespassers playing in sediment would be 1,600 cm². The soil-to-skin adherence factor was assumed to be 1.0 mg/cm²-event, the reasonable upper default value provided in USEPA (1992b). Similar to dermal absorption of chemicals from soil, the amount of chemical in contacted sediment which is absorbed through the skin into the body is needed to estimate the dose resulting from dermal exposures to sediment. The dermal absorption percentages used to estimate exposures via dermal contact with sediment are shown in Table 4-5.

Except for thallium, metals present in inorganic (rather than organometallic) forms are poorly absorbed through intact skin during exposures of short duration (e.g., Moore et al. 1980, Skog and Wahlberg 1964, Wahlberg 1968a,b, Lang and Kunze 1948). Exposure via dermal absorption from contacted sediment is expected to be insignificant for metals, therefore doses via dermal absorption were not calculated for arsenic. Absorption of thallium is assumed to be greater than for other inorganics based on Klaasen et al. (1986).

The LADDs for chemicals exhibiting carcinogenic effects and the ADDs for chemicals exhibiting noncarcinogenic effects associated with the dermal absorption of chemicals from Sequoit Creek sediment at the H.O.D. Landfill site are summarized in Table 4-12.

The potential skin cancer risks associated with dermal contact with carcinogenic PAHs in sediment were estimated using the same methodology outlined for dermal exposure to soil. Hence, LADDs were not calculated for carcinogenic PAHs. Rather, skin cancer risks associated with contact of PAHs in sediment by current child/teenage trespassers will be presented in Section 5 (Risk Characterization).

4.4.1.7 Ingestion of Groundwater

Chemical doses were calculated for the residential use of groundwater as drinking water based on the exposure point concentrations of each chemical of potential concern in each well grouping. The exposure parameters for the groundwater ingestion pathway are presented in Table 4-13.

Drinking water exposures were evaluated for an adult resident using USEPA default values. Default assumptions of a 70 kg body weight and a 2 liter/day ingestion rate were used based on USEPA (1991, 1989a). The standard default (USEPA 1991) residential exposure frequency for the ingestion of groundwater of 350 days/year was assumed. An exposure duration of 30 years was based on the national upper bound time at one residence (USEPA 1991, 1989a). The averaging time for carcinogens is based on a lifetime estimate of 70 years (25,550 days) as recommended in USEPA (1991, 1989a). The averaging time is equal to the exposure duration (10,950 days) for noncarcinogens. The equation used to derive the ADDs and LADDs associated with ingestion of groundwater as drinking water is presented in Appendix C. LADDs for chemicals exhibiting carcinogenic effects and ADDs for chemicals exhibiting noncarcinogenic effects due to ingestion of groundwater by residents are summarized in Tables 4-14 and 4-15 for the selected groundwater well groupings.

4.4.1.8 Inhalation Exposures While Showering

Inhalation exposures to volatile chemicals while showering with groundwater were calculated for nearby residents. Exposure point concentrations in shower room air were based on the exposure point concentrations in groundwater identified for the volatile organic chemicals of potential concern in each well grouping. The shower room concentrations were calculated using a shower model as described in Subsection 4.3.1.4.

The parameters used to assess inhalation exposures while showering are shown in Table 4-16. Default parameter values specified by USEPA (1991, 1989a) were used to assess this pathway. These include an exposure time of 17 minutes [12 minutes with the shower on (USEPA 1989a) and 5 minutes in the shower room after the shower is turned off], a frequency of exposure of 350 days/year, an exposure duration of 30 years, and an expected lifetime of 70 years.

As described above, for inhalation pathways, inhalation exposure concentrations (IECs) were calculated (rather than doses), since the toxicity criteria for inhalation exposures are expressed in concentration units. Thus, information on the ventilation rate and body weight of residential receptors was not taken into account when estimating inhalation exposures (USEPA assumes that the receptor inhales 20 m³/day, 365 days/year for 70 years and weighs 70 kg when developing toxicity criteria). IECs were calculated by adjusting the shower room air concentration of each chemical of concern to account for differences between the exposure assumptions under the residential showering scenario

(less than constant exposure) and those used to derive the inhalation toxicity criteria (constant exposure). The IECs calculated for this pathway for each of the groundwater well groupings are summarized in Table 4-17.

4.4.1.9 Dermal Exposure While Showering

Direct contact with chemicals of potential concern in groundwater during showering by nearby residents was quantitatively evaluated in this assessment. This pathway was evaluated for private wells, public supply wells, and off-site monitoring well groundwater data. The exposure parameters selected to evaluate chemical doses by adults contacting groundwater while showering are listed in Table 4-16 and described briefly below.

The showering exposure frequency, exposure duration, body weight and averaging time are the same as those described for inhalation of volatile organic chemicals while showering. The skin surface area available for dermal contact with shower water was assumed to be 20,000 cm². This value was based on USEPA (1992b) and USEPA Region V specifications. The shower exposure time for dermal exposure was assumed to be 0.2 hours/day. This value is based on the 90th percentile shower time (12 minutes) provided by USEPA guidance (USEPA 1989a). It was assumed that an individual would shower once per day.

When evaluating exposures from dermal contact with groundwater, a chemical-specific permeability constant (described earlier for dermal exposure to surface water) was applied to the exposure calculations to describe the movement of the chemical across the skin to the stratum corneum into the bloodstream. Permeability coefficients for the chemicals of potential concern for the various groundwater groupings were presented previously in Table 4-8.

The equation used to derive the ADDs and LADDs associated with dermal exposure to chemicals in groundwater while showering is presented in Appendix C. LADDs for chemicals exhibiting carcinogenic effects and ADDs for chemicals exhibiting noncarcinogenic effects due to dermal contact with groundwater by residents are summarized in Tables 4-18 and 4-19 for the selected groundwater well groupings.

4.4.1.10 Inhalation Exposures From Landfill Emissions

Inhalation exposures to nearby residents from volatile chemicals emitted from the landfill were also calculated. Exposure point concentrations were derived from the landfill gas measurements using an emissions model and an air box model, as described in Section 4.3.1.5.

The parameters used to assess this pathway are shown in Table 4-20. Default values specified by USEPA (1991, 1989a) were used for all parameters. The inhalation exposure concentrations (IECs) were calculated in a manner similar to that used for shower IECs, with adjustments made to account for differences in exposure frequency and duration. The IECs, ADDs and LADDs calculated for this pathway are shown in Table 4-21.

4.5 COMPARISON TO MCLs, MCLGs, AND STATE STANDARDS

At the request of USEPA Region V, and in accordance with USEPA (1993b) guidance regarding presumptive remedies for municipal landfill sites, the on-site groundwater concentrations were compared to available federal and state drinking water standards and goals. For this comparison, federal maximum contaminant levels (MCLs), MCL Goals (MCLGs) and available Illinois groundwater quality standards were compiled for the COPCs in on-site groundwater. Table 4-22 presents this comparison, listing the available federal and state drinking water information in addition to summary statistics for each COPC.

This table shows that mean and maximum thallium concentrations in on-site deep sand and gravel groundwater exceeded the Federal MCLG. The maximum thallium concentration was essentially the same as the Federal MCL and Illinois Groundwater Quality Standard. Of the 3 samples from this groundwater data set analyzed for thallium, however, only one contained a detectable level of the compound. In the on-site surficial sand groundwater, mean and maximum concentrations of manganese exceeded the Federal MCLG and Illinois Standard. Also in the on-site surficial sand groundwater, mean and maximum concentrations of vinyl chloride exceeded the Federal MCL and Illinois Standard. However, vinyl chloride was only detected in one of 12 samples analyzed in this data set, and thus the mean concentration predominantly reflects this compound's detection limit.

5.0 RISK CHARACTERIZATION

In this section, the human health risks potentially associated with the selected human exposure pathways are assessed. To quantitatively assess risks at the H.O.D. Landfill site, the average daily doses (LADDs and ADDs) and inhalation exposure concentrations (IECs) calculated in the exposure section are combined with the health effects criteria presented in the toxicity section. The USEPA (1986a,b, 1989, 1992a) has developed guidance for assessing the potential risks to individuals from exposure to carcinogenic and noncarcinogenic chemicals. The USEPA uses separate methodologies for estimating the risks from these two different classes of compounds.

For oral exposures to chemicals exhibiting carcinogenic effects, the individual upper bound excess lifetime cancer risks were calculated by multiplying the estimated LADD by the upper bound cancer slope factor. For inhalation exposures to chemicals exhibiting carcinogenic effects, calculated IECs were multiplied by the appropriate cancer unit risks to derive individual upper bound excess lifetime cancer risks. Upper bound is a term used by the USEPA to describe cancer slope factors and unit risks, meaning that actual risks are unlikely to be higher than the risks predicted using the upper bound cancer slope factors or unit risks. A risk level of 1×10^{-6} , for example, represents an upper bound probability of one in one million that an individual could contract cancer as a result of exposure to the potential carcinogen over a 70-year lifetime under the specified exposure conditions. It is important to note that although the upper bound cancer risk estimates provide plausible estimates of the upper limits of risk, the actual risk could be considerably lower. In order to assess the upper bound individual excess lifetime cancer risks associated with simultaneous exposure to all chemicals of potential concern, the risks derived from the individual chemicals were summed within each exposure pathway. This approach is consistent with the USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA 1989).

Potential risks for noncarcinogens were calculated by means of a hazard index technique as recommended by USEPA (1989). For oral exposures, the ratio of the ADD to the reference dose (ADD:RfD) was derived for each chemical. For inhalation exposures, the ratio of the IEC to the reference concentration (IEC:RfC) was derived. Values of these ratios, called hazard quotients, that are greater than one (1) are indicative of a potential for adverse health effects. The effects from simultaneous exposures to all chemicals of potential concern were computed by summing the individual ratios (hazard quotients) within each exposure pathway. This sum, known as the hazard index, serves the same function for the mixture as the hazard quotient does for the individual compound. In general, hazard indices which are less than one are not likely to be associated with

any health risks, and are therefore less likely to be of regulatory concern than hazard indices greater than one. If a hazard index calculated in this assessment was greater than one, the chemicals of potential concern were subdivided into categories based on target organ affected by exposure (e.g., liver, kidney, etc.) in accordance with USEPA guidance (USEPA 1989). Hazard indices were then recalculated for these categories to better identify the likelihood that noncarcinogenic effects might occur.

The evaluation of dermal exposures, in contrast to oral and inhalation exposures, is complicated by the fact that toxicity criteria for this route of exposure are unavailable. As a result, oral toxicity criteria (cancer slope factors or RfDs) were used to assess dermal exposure estimates (LADDs or ADDs). In order to compare the dermal dose estimates, which represent internal (or absorbed) doses, to the toxicity criteria, which typically represent potential (or administered) doses, one or the other should be *modified such that equivalent doses are represented.* (In cases where the toxicity criteria are based on internal doses, this modification is not required.) The method for modifying toxicity criteria involves identifying an absolute oral absorption factors for each chemical and using it to increase the oral cancer slope factor for that chemical, or decrease that chemical's RfD. Cancer slope factors and RfDs adjusted in this manner are then used to assess absorbed dose-response, rather than administered dose-response. The absolute oral absorption factors which are applied in theory should reflect the specific conditions under which the toxicological study was conducted (e.g., method of administration such as gavage, water or diet, and vehicle of administration such as solvent or solution). In many cases, however, these data were not available for the selected chemicals. This adds uncertainty to results for the dermal pathways.

Table 5-1 presents the absolute oral absorption factors used to adjust the oral toxicity criteria for the chemicals of potential concern evaluated in dermal pathways (i.e., dermal absorption from surface soil, surface water and sediment). Most values were derived from data presented in the Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile documents. One value was provided by USEPA's Environmental Criteria and Assessment Office (ECAO) and one value was derived from USEPA's Integrated Risk Information System (IRIS). For those chemicals for which sufficient information was lacking, a default absolute oral absorption factor of one (1) was used (i.e., oral toxicity criteria were not changed). The potential impact of this uncertainty is discussed in the uncertainty section of this assessment (Section 7).

The upper bound lifetime excess cancer risks and hazard index values derived in this report can be put into context by considering USEPA's OSWER Directive 9335.0-30 (USEPA 1991) as follows:

Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4} , and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts. However, if MCLs or non-zero MCLGs are exceeded, action generally is warranted.

An alternative approach was used to evaluate risks associated with dermal contact of carcinogenic PAHs in surface soil and sediment. Because carcinogenic PAHs are known to cause skin cancer with sufficient direct contact, such exposures can result in elevated cancer risks. To date, USEPA has not developed a methodology for evaluating the potential effects on the skin from dermal contact with PAHs. The approach used in this risk assessment was outlined previously in Section 4.4.1.2. Dermal exposure to carcinogenic PAHs in units of $\mu\text{g}/\text{cm}^2\text{-day}$ exposed skin were estimated using the equation presented in Section 4.4.1.2. Dermal exposures were also calculated in units of $\mu\text{g}/\text{cm}^2$ by multiplying the dermal exposures in $\mu\text{g}/\text{cm}^2\text{-day}$ by the total number of days per year the individual is assumed to be exposed. This conversion is necessary because certain experimental studies present exposures in units of $\mu\text{g}/\text{cm}^2\text{-day}$ (Habs et al. 1980). The concentrations of carcinogenic PAHs in surface soil and sediment were used to calculate dermal exposures (in units of $\mu\text{g}/\text{cm}^2$ and units of $\mu\text{g}/\text{cm}^2\text{-day}$) and then compared to experimental data (see Table 3-3) to estimate potential cancer risks.

5.1 RISKS ASSOCIATED WITH EVALUATED EXPOSURE PATHWAYS

The risk estimates for each pathway evaluated are presented in Tables 5-2 through 5-13. Risks associated with incidental ingestion and dermal absorption of surface soil are shown first (Tables 5-2 and 5-3), followed by risks associated with dermal absorption of surface water (Table 5-4), risks associated with incidental ingestion and dermal absorption of sediment (Tables 5-5 and 5-6), risks associated with ingestion of groundwater (Table 5-7 and 5-8), risks associated with inhalation of volatile organic chemicals in groundwater and dermal contact with groundwater while showering (Tables 5-9 through 5-11), and finally, risks associated with inhalation of VOCs from the landfill surface (Table 5-12). The potential for skin cancer risks from direct contact with carcinogenic PAHs is shown in Table 5-13.

A summary of the results are shown in Table 5-14. This table shows that excess lifetime cancer risks for the RME case exceed 10^{-4} ($1\text{E-}04$) for only one chemical in one pathway, ingestion of vinyl chloride from off-site deep sand and gravel aquifer groundwater. These risk estimates conservatively assume

that an individual would be exposed to the maximum detected concentration in one well of vinyl chloride 350 days/year for 30 years, even though there is no actual current use of water from the off-site deep sand and gravel monitoring wells. The excess lifetime cancer risks from inhalation and dermal absorption of vinyl chloride while showering with off-site deep sand and gravel groundwater collectively add a risk of 9×10^{-5} to the ingestion risk of 8×10^{-4} . The available groundwater data do not conclusively indicate a clear pattern of association of vinyl chloride with the site, since this chemical was detected infrequently and at lower concentrations in leachate (1 out of 5 samples at 18 ug/L) and on-site surficial sand groundwater (1 out of 12 samples at 19 ug/L) compared to off-site deep sand and gravel groundwater (2 out of 4 samples at 28 ug/L and 35 ug/L). Vinyl chloride was not detected in on-site deep sand and gravel groundwater or in off-site surficial sand groundwater. Vinyl chloride is, however, a common byproduct at waste landfills and is present in on-site surficial sand groundwater and landfill gas samples.

A few other chemicals had an excess lifetime cancer risk greater than 1×10^{-6} ($1 \text{E-}06$) or a hazard index value greater than one.

- beryllium - ingestion and dermal absorption while showering with off-site surficial sand and gravel aquifer groundwater,
- arsenic - ingestion of municipal well water, and
- manganese - ingestion of off-site surficial sand groundwater.

These results should be considered in context with their associated important uncertainties.

- Beryllium was selected as a chemical of concern in off-site surficial sand groundwater because no background dissolved groundwater data were available. It was only detected in 1 of 4 samples from off-site surficial sand groundwater at a concentration of 0.95 ug/L. Beryllium was not, however, detected in on-site surficial sand or deep sand and gravel groundwater, or in off-site deep sand and gravel groundwater. It was detected in 1 of 34 regional background samples (total not dissolved) at a concentration of 1 ug/L. These data suggest that beryllium may not be a site-related chemical.
- Arsenic was selected as a chemical of concern in municipal wells because fewer than 3 samples were available, and thus, according to USEPA Region V direction for this risk assessment, the chemical was selected by default. The two detected concentrations of arsenic in municipal well samples, 2.1 ug/L and 4.3 ug/L, are well below the federal MCL of 50

ug/L and below the range of regional background levels of 1- 26 ug/L. These conclusions, in conjunction with the fact that arsenic was not a selected chemical of concern in any other groundwater data set, indicate that arsenic is not a site-related chemical.

- The method used to calculate risks from dermal exposure to water while showering for beryllium and vinyl chloride is very uncertain. It is based on an unvalidated model presented in an "Interim Report" prepared by USEPA for assessing dermal risks (USEPA 1992b). Further, since there are no toxicity data available based on the dermal route of exposure, the use of oral toxicity data to evaluate this pathway adds uncertainty to the results.
- The manganese concentration in the off-site surficial sand groundwater used to calculate long-term risks was the single maximum detected value in one well. The manganese concentrations detected in the other off-site surficial sand monitoring wells were all at least ten times lower than the maximum. All of the detected manganese concentrations in off-site surficial sand groundwater wells were less than the levels at which minor neurological effects (based on neurologic exam scores) have been observed in individuals chronically exposed to manganese in drinking water (Kondakis et al. 1989). Also, there is no actual current use of water from the off-site surficial sand monitoring wells.

As discussed in Section 4, the concentrations of a few chemicals in on-site groundwater exceeded federal or state standards. Thallium was present in on-site deep sand and gravel groundwater at levels exceeding the federal MCLG and similar to the federal MCL and Illinois groundwater quality standard. However, these results are based on only a single detection of thallium in this aquifer data set. Thallium was not detected in any of the other groundwater data sets. Manganese was present at levels in on-site surficial sand groundwater above the federal MCLG and Illinois standard. Vinyl chloride was also detected once (out of 12 samples) in on-site surficial sand groundwater at a level above the federal MCL and Illinois standard.

6.0 ECOLOGICAL ASSESSMENT

This section evaluates potential ecological risks associated with COPCs for the H.O.D. Landfill site. The approach used to assess ecological risks is based on the general conceptual framework for ecological risk assessment outlined by the U.S. Environmental Protection Agency (USEPA 1992a), and is consistent with other ecological assessment guidance published by USEPA (1989a,b) and USEPA Region V (USEPA 1992b). Under this approach, information on the occurrence and distribution of potential receptors is combined with information on exposure potential and toxicity to characterize ecological risks.

This assessment is based primarily on chemical concentration data collected during the Remedial Investigation (RI) and on general information on site ecology obtained during site visits and through the use of field guides and contacts with regional wildlife specialists. Much of the supporting data has been presented previously in *Technical Memorandum No. 1 -- Investigation Results and Analysis Report* (Warzyn 1993a) and in the *Ecological Assessment Preliminary Screening Report* (Warzyn 1993b) already submitted to the regulatory agencies by Waste Management of Illinois, Inc. (WMI).

The overall objective of the ecological assessment is to determine if chemical exposures at the site have the potential to alter the structure, function, or interactions of the biological populations or communities of the area. This is accomplished largely by extrapolation of site-specific habitat and chemistry information and literature-based toxicity data to estimate exposure, toxicity, and risk. Bioassessment studies (e.g., toxicity tests, benthic community surveys), which could provide more specific information on potential site-specific impacts or risks, were not conducted at this site because the occurrence and concentration of chemicals in surface waters and soils of the site are such that these additional studies were not deemed warranted (Warzyn 1993b). For similar reasons, the risk assessment presented here is largely qualitative. The nature of the data is such that a quantitative assessment is neither supportable nor warranted. This "desk-top," predictive assessment is consistent with USEPA Region V (USEPA 1992b) guidance Step 2.

The remainder of this assessment is divided into four principal sections:

- Site Characterization and Identification of Potential Receptors,
- Selection of Chemicals of Potential Concern,
- Exposure Potential and Assessment of Risk, and
- Conclusions.

6.1 SITE CHARACTERIZATION AND IDENTIFICATION OF POTENTIAL RECEPTORS

The following section provides a general description of the site and surrounding area and identifies habitats and receptors potentially exposed to chemicals present at or released from the site.

6.1.1 Physical Description of the Site¹

The H.O.D. Landfill site occupies 80 acres within the eastern boundary of the Village of Antioch in Lake County in northeastern Illinois. The site is located in a mixed land-use area consisting of light industrial, residential, agricultural, and undeveloped land. Land use immediately adjacent to the site consists of Sequoit Acres Industrial Park to the west, the Silver Lake residential subdivision and Silver Lake to the east, Sequoit Creek to the south and west, and agricultural land, scattered residences, and undeveloped land to the north. Regional land use is highly agricultural.

The site is situated in the vicinity of the Wheaton moraine within the Great Lakes section of the Central Lowland Province. The topography of the area is characterized by gentle slopes with poorly defined *surface drainage patterns, depressions, and wetlands*. The topography in the immediate vicinity of the site is generally flat. The most prominent topographic feature in the area is the landfill. The maximum elevation of the landfill is approximately 800 feet mean sea level, approximately 30 to 40 feet above Sequoit Creek.

Soils of the area are a mixture of silt and clay loams. Drainage varies and ranges from well drained to moderately well drained loams on slopes and uplands to very poorly drained materials in wetland areas consisting of silty-clayey, water-deposited materials and organic muck.

Surface drainage around the site is toward the Fox River, located approximately 5 miles to the west. Locally, surface water drainage is toward Sequoit Creek. Winds are predominantly from the southwest.

¹Much of the information in this section has been taken directly from the *Ecological Assessment Preliminary Screening Report* (Warzyn 1993b). That report and *Technical Memorandum #1* (Warzyn 1993a) provide a more complete description of the physical characteristics of the site and surrounding area. This section, however, does incorporate information requested by USEPA following the Agency's review of the *Screening Report* prepared by Warzyn (1993b).

6.1.2 Potentially Exposed Habitats and Species

The site is located in the Maple-Basswood Forest section of the Eastern Deciduous Forest province (USDA 1980). The Eastern Deciduous Forest province is characterized by a rolling topography covered by deciduous hardwood forests consisting of oak, beech, birch, hickory, walnut, maple, basswood, elm, ash, and tulip poplar. Pines occur as secondary growth in areas that have been timbered. Substantial portions of the eastern deciduous province have been developed as cropland or pasturage. Abandoned agricultural land creates old-field habitat in various stages of secondary succession.

The region surrounding the H.O.D. Landfill site is predominantly agricultural, consisting of a mixture of cropland and pasturage. Old fields/grasslands and deciduous woodlots dominated by oaks, maples, or basswood are scattered throughout. In addition, freshwater sedge and cattail marshes (palustrine emergent wetlands) occur along drainage ways and in seepage areas.

Habitats on and immediately adjacent to the site consist of fields/grasslands, deciduous woodlots, wetlands, creek, and lake.

6.1.2.1 Fields/Grasslands

The landfill surface and adjacent disturbed land provide field/grassland habitat in the immediate site vicinity. Herbaceous cover consists of a variety of grasses and forbs in the early stages of secondary succession. Cover plants include clover, Queen Anne's lace, thistle, goldenrod, dock, asters, wild strawberry, chicory, cinquefoil, and various grasses. Staghorn sumac also occurs along fence rows.

Bird species observed in the field habitat during site visits conducted in July (by Warzyn) and September (by WEINBERG) of 1993 include barn swallow, mourning dove, swift, sparrow, eastern king bird, American goldfinch, American crow, American robin, red-tailed hawk, and gulls. Other avian species likely to use the field habitats include horned lark, eastern bluebird, common grackle, northern bobwhite, kestrel, and turkey vulture.

Mammalian species (or their sign) observed in the field habitat during the site visits were deer, raccoon, and field mouse/vole. Other probable mammalian residents of the landfill surface and surrounding fields include shrews, cottontail, and red fox. Coyotes were heard calling during the site visit in July.

6.1.2.2 Deciduous Woodlots

Deciduous woodlots occur on site to the south of the landfill and off site to the west and north. Soils associated with the habitat include Miami silt loam, Houghton soils, Zurich and Morely silt loams, Peotone silt loam, Crays silt loam, and Morely silt loam. Characteristic trees include cottonwood, green ash, silver maple, box elder, red mulberry, white oak, and birch. Animal species (or their sign) *observed in the forested areas during the site visit include sparrows, robin, eastern kingbird, goldfinch, meadowlark, deer, raccoon, and coyote.* Other probable avian residents of the forested areas include cardinal, blue jay, black-capped chickadee, tufted titmouse, white-breasted nuthatch, Carolina wren, rufous-sided towhee, woodpeckers, and warblers. Most of the mammals occurring in field habitats are also likely to use the forested areas.

6.1.2.3 Wetlands

A small palustrine scrub-shrub/emergent (PSS/EM) wetland exists at the toe of the landfill to the south, along the northern banks of Sequoit Creek. Willow, cottonwood, and red-osier dogwood are the *predominant shrubs/trees.* *Small pockets of giant reed intermixed with cattails and wetland grasses* also occur. A relatively large (i.e., > 20 acres) cattail marsh (PEM) occurs south of Sequoit Creek. Small pockets of cattail/sedge/rush wetlands occur along ditches and in shallow depressions north of the site. Wetlands soils are within the Houghton series.

6.1.2.4 Aquatic Habitats

Sequoit Creek traverses the southern and western perimeters of the site area. The creek begins as an outfall from Silver Lake, located southeast of the landfill, travels to the west across the southern perimeter of the landfill and then runs north along the western border of the site. The creek is approximately 12 to 15 feet wide. The creek has an extremely low gradient which at times can result in little to no flow. During the September 1993 site visit, no flow was apparent even though it was raining heavily at the time. At that time, water was present in a series of small pools that were interconnected by narrow channels of water. Pools were between 12 and 18 inches deep. Carp, minnows, and a small bass or sunfish were observed in Sequoit Creek. In addition, amphipods, isopods, and mayfly nymphs (all indicators of good water quality) and water boatman and bloodworm were observed in the creek. Duckweed, coontail, and elodea were prevalent throughout the creek. The banks of the creek are moderately sloped and are vegetated with grasses, forbs, trees

(cottonwood, willow), and shrubs. A small forested area occurs near the headwaters of the creek. White oak, box elder, and birch were the predominant trees.

Silver Lake occurs southeast (upgradient) of the site. This lake is a natural "kettle" lake that historically has had a stable and productive fish population including native fishes such as northern pike and smallmouth bass. Carp also are present in the lake.

6.1.2.5 Rare, Threatened or Endangered Species and Their Habitats

Based on information obtained from the Illinois Department of Conservation (IDEC; Dees 1993), no rare threatened, or endangered (RTE) species or their habitats exist on or immediately adjacent to the H.O.D. Landfill site. Three Illinois State Natural Areas (NAs) exist within two miles of the site, however: Loon Lake-East Loon Lake NA located approximately 1.2 miles to the south; Redwing Slough State NA, located approximately 1.2 miles to the east/northeast; and Antioch Bog NA, located approximately 1.5 miles to the southeast. The location of these areas relative to the site area and a listing of the RTE species known to occur in these areas is provided in Appendix D.

6.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

All of the chemical data summarized in the earlier sections of this risk assessment were considered in this ecological assessment. The nature and extent of contamination, discussed in Warzyn (1993a,b), and in the remainder of the RI report also was used.

6.3 COMPARISON OF CHEMICAL CONCENTRATIONS TO APPLICABLE ECOTOXICOLOGICAL GUIDANCE VALUES

Tables 6-1 and 6-2 present a comparison of mean and maximum surface water and sediment chemical concentrations to ecotoxicological guidance values. As can be seen, no maximum chemical concentrations in Sequoit Creek surface water and only fluoranthene in Sequoit Creek sediment are above applicable guidance values. Several inorganic and organic chemicals present in on-site sub-surface leachate are, however, substantially above surface water criteria.

6.4 EXPOSURE POTENTIAL AND ASSESSMENT OF RISK

This section identifies the pathways by which organisms could be exposed to chemicals at the H.O.D. Landfill site and qualitatively estimates potential risks. This information is presented below for each potential exposure medium. Table 6-3 presents a summary of potential exposure pathways, exposures, and risks.

6.4.1 Surface Water

Aquatic life can be exposed to chemicals present in surface water via respiration, dermal absorption, and ingestion. Terrestrial wildlife can be exposed to chemicals present in surface water via intentional or incidental ingestion of surface water, dermal absorption while foraging, or ingestion of chemicals that have accumulated in aquatic prey.

Chemicals of potential concern can be released to surface water via groundwater discharge, surface transport of leachate from seepage areas, and surface runoff of soil-sorbed chemicals. Once released to surface water, chemicals can volatilize, sorb to sediments, or be dispersed in the water column. Based on site-specific surface water and groundwater hydrology, Sequoit Creek would be the ultimate recipient of the majority of chemicals released via these transport pathways.

Chemical sampling of shallow groundwater near Sequoit Creek implicates this medium as a likely source of chemicals to the creek, given that chemicals have been detected in shallow groundwater and that groundwater is known to discharge to the creek. Chemical concentrations in shallow groundwater are relatively low, however, (e.g., VOCs at 1 to 35 $\mu\text{g/l}$), suggesting that the overall contribution of groundwater to surface water is not likely significant with respect to ecological exposures.

Leachate also is implicated as a source of chemicals given that chemicals have been detected in the subsurface leachate samples and that leachate seeps are present on the sides of the new landfill. No leachate samples were collected from the surface seepage areas, although soil samples collected from these areas contained detectable levels of organic and inorganic chemicals. Overall the concentrations of the chemicals in these soils were low (i.e., PAHs and miscellaneous semi-volatiles in the range of < 100 to 300 $\mu\text{g/kg}$), suggesting that the surface seeps are not a major source of semi-volatiles or metals. (It is possible that these seeps are a source of volatile chemicals which could not be measured in soil samples. However, volatile chemicals released to surface seeps would partition to

air principally and therefore would not be a source of chemicals to surface waters.) Therefore, although chemicals are likely being transported to surface water from shallow groundwater and leachate seeps, the chemical data collected from these source areas suggest that this contribution is not likely to greatly affect water quality.

Surface water sampling in Sequoit Creek confirms this. As shown previously in Table 2-3, few chemicals were detected in Sequoit Creek surface water. Of the inorganic chemicals, only antimony, barium, lead, and iron were not eliminated from risk evaluation based on a comparison to background concentrations. Of these, antimony and lead were detected in downgradient creek samples at concentrations that were less than the detection limits that were achieved for the background samples, and very probably are not present in downgradient samples at concentrations that are above background. Barium was detected in the background samples, but at concentrations that were in the same range as those detected in downgradient samples (i.e., 18 to 22 $\mu\text{g/L}$), suggesting that the selection of barium as a chemical of potential concern for the creek is more likely a function of the small sample size available for the statistical test rather than its presence in downgradient samples at concentrations that are above background. Only iron was detected in Sequoit Creek surface waters at concentrations that suggest it is elevated above background. Nevertheless, the maximum detected concentration of iron (420 $\mu\text{g/L}$) is well below the chronic ambient water quality criterion (AWQC) of 1,000 $\mu\text{g/L}$ established for this chemical (see Table 6-1), suggesting that the chemical poses no threat to aquatic life. 2-Hexanone and 4-methyl-2-pentanone were the only organic chemicals detected in Sequoit Creek surface water, and although no AWQC or other ecotoxicological guidance values have been established for these chemicals, the single detected concentrations of 2 to 3 $\mu\text{g/L}$ are not likely to pose a threat to aquatic life. A fish LC_{50} of 460,000 $\mu\text{g/L}$ has been reported for 4-methyl-2-pentanone (Vershueren 1983). A similar toxicity is expected for 2-hexanone, which is molecularly similar to 4-methyl-2-pentanone.

Terrestrial wildlife also are unlikely to be affected by the concentrations of chemicals in the creek. For example, the toxicological limit of iron in mammals is 5 g/kg bw (Jorgensen et al. 1991), which is substantially above that which could be obtained by ingesting surface water from the creek. No toxicological data were found for the detected organic chemicals, but neither is expected to be toxic at the 2 to 3 $\mu\text{g/L}$ level. None of the detected chemicals will bioaccumulate in aquatic prey, and therefore food-chain exposures are not of concern.

6.4.2 Sediment

Chemicals transported to surface water via the pathways discussed above can sorb to sediments and thus be a source of potential exposure for ecological receptors. Aquatic life can be exposed to chemicals present in sediments via ingestion or direct contact. Terrestrial wildlife can be exposed to chemicals present in sediment via incidental ingestion while foraging or ingestion of chemicals that have accumulated in aquatic prey. Only PAHs, arsenic, and thallium were detected in Sequoit Creek sediments at concentrations that are potentially associated with the site. With the exception of phenanthrene in a single sample, PAHs and arsenic were detected at concentrations that were generally below the screening-level sediment guidance values that have been developed for these chemicals (see Table 6-2) and based on this comparison, these chemicals do not appear to pose a threat to aquatic life of the creek. Similar aquatic life guidance values have not been developed for thallium, but overall this chemical is relatively non-toxic to aquatic life, with LC_{50} values for freshwater fish and invertebrates in the range of 10,000 to 170,000 $\mu\text{g/L}$ (Vershueren 1983). Terrestrial wildlife are also unlikely to be at risk from exposure to creek sediment chemicals at the concentrations detected.

6.4.3 Surface Soil

Terrestrial wildlife can be exposed to soil-sorbed chemicals via ingestion while foraging or grooming, dermal absorption of chemicals in contact with the skin, or ingestion of chemicals that have accumulated in prey. Although chemicals have been detected in the soils of the seepage areas and *wildlife could use these areas and thus be exposed, the overall risk associated with these exposures is low because chemical concentrations are low relative to potentially toxic concentrations.* For example, the sample-specific maximum concentration of PAHs (the predominant organic chemicals in soil) is 2.8 mg/kg (at SU02), which is well below the *dietary* concentration of 825 mg/kg diet associated with minimal toxicity in deer mice and house mice (Eisler 1987). Given that a mouse diet would not consist entirely of soil nor be obtained only from the maximum concentration location, even the maximum concentrations should not pose any threat to terrestrial wildlife. Assuming other terrestrial wildlife are not 400 times more sensitive than mice, the levels are unlikely to present a hazard to wildlife. Other factors contributing to probable low risks are: (1) the sporadic distribution of chemicals in surface soils of the site that would likely result in sporadic wildlife exposure; and (2) the fact that none of the detected chemicals bioaccumulates in terrestrial food chains.

Terrestrial plants could be exposed to chemicals in surface soils via uptake through the roots or stomatal absorption of airborne chemicals. Few toxicological data are available to assess the potential toxicity of the chemicals of potential concern to plants. However, based on observations of the condition of plants near the largest leachate seep, local vegetation appears to be unaffected. Warzyn (1993b) observed that vegetation within the primary leachate seep area appeared to be healthy, although the vegetation in the saturated stream of the seep appeared to grow less densely. Warzyn, however, suggests that this could have occurred because soils in that area were saturated with water. No other signs of possible chemical-induced vegetative stress were observed at the site.

6.4.4 Air

Terrestrial wildlife could be exposed via inhalation of chemicals that volatilize from the landfill surface or from surface water following groundwater discharge. Burrowing and soil-dwelling species (e.g., shrews, voles, earthworms) are likely to experience the greatest exposures because they can be exposed to chemicals in soil gas prior to dispersion and dilution of the gas on the landfill surface. Landfill gas samples collected from the site contained volatile organic chemicals at average concentrations in the range of < 500 to 30,000 ppb. Chemical criteria for the protection of wildlife species from exposure to airborne chemicals have not been established, making an impact evaluation of these concentrations difficult. The measured concentrations, however, are below threshold limit values (TLVs) established for protection of human workers. Assuming wildlife species are no more sensitive than humans to inhalation exposures of volatile chemicals, the concentrations measured in the landfill gas are not likely to cause adverse effects in soil dwelling species. Exposures and risks in non-subterranean wildlife would be substantially less given that volatile chemicals would be rapidly dispersed and diluted across the landfill surface.

Terrestrial plants could be exposed to landfill gas via stomatal uptake. No data were located on the effects of volatiles on natural plant communities, but as stated above, visual observations of the vegetative communities of the site indicate a healthy plant community.

6.4.5 Leachate Seeps

Terrestrial wildlife could be exposed to chemicals present surface leachate via ingestion of leachate or incidental ingestion of soil while drinking from the seep. No data are available on chemical concentrations in surface seeps, although data are available for subsurface leachate collected from leachate piezometers and a subsurface manhole. These data might be representative of chemical

concentrations in surface seeps, but comparison of the subsurface leachate data with soils samples collected from the surface seeps suggests that the leachate reaching the surface seeps probably has a different chemical composition. PAHs and volatiles were the principal organic chemicals detected in seep soil samples whereas volatiles and semi-volatile phenols, ketones, and phthalates were the principal organic chemicals detected in subsurface leachate. Eleven different PAHs were detected the surface seep soil samples compared to only one PAH in the subsurface leachate.

Because there is some uncertainty regarding the character of the leachate reaching surface seeps, it is difficult to evaluate potential risks to terrestrial wildlife. Nevertheless, terrestrial wildlife exposure to chemicals present in leachate is expected to be limited because: (1) surface seeps flow only intermittently, and (2) other surface water that could serve as a source of drinking water for wildlife is accessible and prevalent in the surrounding area. It is considered unlikely that the concentrations in surface leachate could be such to cause toxicity in intermittently exposed wildlife. For example, the concentrations that were detected in subsurface leachate, though elevated, are below those that are likely to associated with acute toxicity in wildlife. The leachate could be toxic to invertebrate life such as larval insects, if the seeps are used as seasonal breeding areas. As shown in Table 6-1, the concentrations of many of the chemicals detected in leachate seep water are above those that could be toxic to certain aquatic life. The overall effect of such toxicity, if occurring, on the invertebrate communities of the study area is anticipated to be very low however, given the size of the seeps relative to other available habitat in the area.

Terrestrial plants could be exposed to surface leachate via uptake through roots or leaves. However, as discussed above, visual observation suggests that the plants near the largest leachate seep are unaffected.

6.5 CONCLUSIONS

Pathways exist by which aquatic and terrestrial wildlife might be exposed to chemicals of potential concern present at or migrating from the H.O.D. Landfill. Overall, however, chemical concentrations are such that potential risks to plants, aquatic life, and terrestrial wildlife are estimated to be minimal. Visual observations of the character and composition of the terrestrial and aquatic communities of the site suggest a relatively "healthy" community. These observations combined with predictions of low exposure and risk support the conclusion that biological populations and communities of the area have not been adversely affected by chemicals present at or migrating from the H.O.D. Landfill site.

7.0 UNCERTAINTIES

As in any risk assessment, the estimates of risk for the H.O.D. Landfill site have many associated uncertainties. In general, the primary sources of uncertainty are the following:

- Environmental sampling and analysis, and selection of chemicals
- Exposure parameter estimation
- Toxicological data

Some of the more important sources of uncertainty in this assessment are discussed below. As a result of the uncertainties described below, this risk assessment should not be construed as presenting an absolute estimate of risk to persons potentially exposed to chemicals at or near the H.O.D. Landfill site. Rather, it is a conservative analysis intended to indicate the potential for adverse impacts to occur.

7.1 ENVIRONMENTAL SAMPLING AND ANALYSIS, AND SELECTION OF CHEMICALS

Table 7-1 summarizes some of the uncertainties related to environmental sampling and analysis and selection of chemicals of potential concern. Environmental chemistry analysis error can stem from several sources including errors inherent in the sampling or analytical methods. Also, the amount of rejected data (denoted by R qualifiers in the validated RI data) can decrease the available data for determination of exposure point concentrations. Some data collected during the RI were rejected: results for acetone in sediment and for acetone, 2-butanone, and 2-hexanone in private and municipal wells were classified as "R." Additional uncertainty is associated with chemicals reported in samples at concentrations below the reported quantification limit, but still included in data analysis, and with those chemicals qualified with the letter J, indicating the concentrations are estimated. A significant portion of the data for each medium were associated with J qualifiers. The percentages of data reported as estimates are as follows: 26% of private and municipal well data, 28% for surface water, 30% for monitoring well data, 44% for leachate, 51% for soil, and 63% for sediment. Analysis uncertainties such as these may result in the over- or underestimation of risk.

For some investigated environmental media, just a few locations were sampled, thus limiting the level of confidence in the representativeness of the data to characterize environmental concentrations. For example, five locations were sampled for landfill soil, and no samples were identified as being suitable

for background. Regional background surface soil data for nearby counties were obtained from a U.S. Geological Survey source and considered to be representative of site soil background conditions. Similarly, for groundwater, only a few samples were identified as background for the various groundwater groupings and regional background groundwater data obtained from the State of Illinois were also used as a comparison in the selection of chemicals of potential concern.

The number of site-specific background samples available to compare with site-related concentrations affects the level of uncertainty associated with the selection of chemicals of potential concern. Use of a statistical test of significance is preferable to direct comparisons in selecting chemicals of potential concern. In this assessment, the Cochran's approximation to the Behrens-Fisher (CABF) t-test was used where at least three site and three background samples were available. If fewer than three samples, or no background data, were available, the chemical was selected by default in accordance with the Risk Assessment Technical Work Plan. This approach is conservative, resulting in a high chance of selecting a chemical when in fact there is no difference between background and site-related concentrations (i.e., a Type I error).

Another uncertainty associated with the selection of chemicals of potential concern was that the selection based on background was limited to inorganics. It is possible that some of the organic chemicals detected in surface soil and sediment may be present at background levels. For example, polycyclic aromatic hydrocarbons (PAHs) are associated with anthropogenic combustion activities and agricultural activities.

7.2 EXPOSURE PARAMETER ESTIMATION

There are two major areas of uncertainty affecting exposure parameter estimation. The first relates to estimation of exposure point concentrations. The second relates to parameter values used to estimate chemical exposures (as either average daily doses or inhalation exposure concentrations).

Table 7-2 summarizes some of the major uncertainties associated with estimation of exposure point concentrations. In particular, the approach used to select exposure point concentrations may overestimate potential exposures and thus risks. In accordance with USEPA (1989, 1992a) guidance, the exposure point concentration for a specific chemical in a particular medium was based on the 95% upper confidence limit (UCL) on the population mean, or maximum detected concentration, whichever was less. Since the 95% UCL is highly unstable from a mathematical standpoint, and is strongly

influenced by the sample size and geometric standard deviation (GSD) of the chemical concentrations being evaluated, the approach to estimating exposure point concentrations often results in the default use of the maximum detected concentration. In the H.O.D. Landfill Risk Assessment, for example, exposure point concentrations for the majority of the chemicals in the evaluated media were based on the maximum detected concentrations. Since the assumption that long-term contact with the maximum concentration is very conservative, the use of maximum concentrations in the risk assessment resulted in extremely conservative estimates of exposures and risks. The use of environmental fate and transport models in calculating concentrations in shower room air and ambient concentrations from landfill gas emissions are also associated with uncertainty.

When calculating exposure point concentrations from sampling data, 1/2 of the reported detection limits for non-detect samples were included in the calculation of the 95% UCL if 1/2 of the detection limit was not greater than the maximum measured value. Any approach dealing with non-detected chemical concentrations is associated with some uncertainty. This is because the non-detect result does not indicate whether the chemical is absent from the medium, present at a concentration just above zero, or present at a concentration just below the detection limit.

Uncertainties associated with the estimation of chemical doses are highlighted in Table 7-3. For example, uncertainties are inherent in the selection of pathways for evaluation. In particular, it was assumed that individuals at the site area would engage in certain activities that would result in exposures for each selected pathway. This assumption is conservative, in that it is in fact more likely that the activity patterns assumed to occur in this analysis only occasionally occur, if at all. Furthermore, even if an individual were to engage in an activity evaluated in the assessment, it is not necessarily true that an exposure would occur. For example, it is unlikely that every time an individual trespasses on the landfill (assuming this were to occur), he or she will contact and incidentally ingest surface soils.

The exposure parameter values used for the RME scenario are also uncertain. In most cases, values for the RME case were specified in USEPA guidance documents (USEPA 1989, 1991). Many of these values are conservative and are based on subjective interpretations of limited data. An example is soil ingestion rates. Current USEPA guidance recommends default soil ingestion rates of 200 mg/day for young children and 100 mg/day for older individuals including adults. Data from Thompson and Burmaster (1991) indicate that the mean soil ingestion rate for children is approximately 62 mg/day. The available data on incidental soil ingestion for adults is almost nonexistent. One study by

Calabrese et al. (1990) on six adults shows an average adult soil ingestion rate of 41 mg/day for the three most reliable tracer elements.

Evaluation of the dermal exposure pathway is also affected by significant uncertainties. Uncertainties are associated with the selection and use of the dermal absorption fractions for contact with soil and sediment, the dermal permeability coefficients for contact with surface water, and the recently recommended (USEPA 1992b) nonsteady-state approach for estimating the dermally absorbed dose from water. *Very limited information is available on the dermal absorption of chemicals from contacted soil under realistic environmental conditions.* In fact, there are no actual human epidemiological data to support the hypothesis that absorption of soil bound organics is a complete route. Where possible, this assessment has used data from experimental studies to determine dermal absorption fractions. In the absence of such data, conservative default values were used (e.g., 0.10 for volatile organics). The uncertainty inherent in these values, however, may result in an under- or overestimation of risk.

The dermal permeability coefficients for surface water contact used in this assessment were derived from USEPA (1992b). Where available, experimental values were used; in their absence, permeability coefficients for organics were estimated using an equation recommended by USEPA (1992b), and a conservative default permeability coefficient was used for inorganics. The uncertainty in the estimated values was *"judged to be within plus or minus one order of magnitude from the best fit value"* (USEPA 1992b). USEPA's (1992b) nonsteady-state approach used to calculate the dermal dose of organic chemicals from contact with surface water has yet to be fully validated and finalized. Initial testing has shown that the new approach provides a more conservative total absorbed dose than the traditional steady-state equation, and in some cases, has raised concerns that the model is overly conservative.

7.3 TOXICOLOGICAL DATA

The toxicological data used in this report also contributes to uncertainty. Table 7-4 summarizes some of the uncertainties inherent in the toxicity assessment. Some of the chemicals of potential concern could not be quantitatively evaluated because sufficient toxicity information was not available to derive oral or inhalation toxicity criteria. *The lack of toxicity criteria for these chemicals is not expected to result in a significant underestimation of risks.*

Toxicological data error is also a large source of uncertainty in this risk assessment. As USEPA notes in its Guidelines for Carcinogenic Risk Assessment (USEPA 1986a):

There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns and other cultural factors.

There is also a great deal of uncertainty in assessing the toxicity of a mixture of chemicals. In this assessment, the effects of exposure to each contaminant present has initially been considered separately. However, these substances occur together at the site, and individuals may be exposed to mixtures of the chemicals. Prediction of how these mixtures of toxicants will interact must be based on an understanding of the mechanisms of such interactions. The interactions of the individual components of chemical mixtures may occur during absorption, distribution, metabolism, excretion, or activity at the receptor site. Individual compounds may interact chemically, yielding a new toxic component or causing a change in the biological availability of an existing component, or may interact by causing different effects at different receptor sites. Suitable data are not currently available to rigorously characterize the effects of chemical mixtures similar to those present at the H.O.D. Landfill. Consequently, as recommended by USEPA (1986b, 1989), chemicals present at the site were assumed to act additively, and potential health risks were evaluated by summing excess lifetime cancer risks and calculating hazard indices for noncarcinogenic effects. This approach to assessing risk associated with mixtures of chemicals assumes that there are no synergistic or antagonistic interactions among the chemicals considered and that all chemicals have the same toxic end points and mechanisms of action. To the extent that these assumptions are incorrect, the actual risk could be under- or overestimated.

For inhalation pathways, unit risks and reference concentrations were used with no adjustments for potential differences in ventilation rate or body weight for exposure concentrations. This may result in the over- or underestimation of risks. For dermal pathways, there is uncertainty associated with the fact that there are no toxicity values (RfDs and cancer slope factors) that are specific to the dermal route of exposure. To evaluate the dermal pathway, therefore, absorbed dermal doses were combined with oral toxicity values. As described previously (see Section 5.0), the oral toxicity values, typically expressed in terms of potential (or administered) doses, were adjusted when assessing the dermal doses, expressed as internal (or absorbed) doses. In this assessment, absolute oral absorption factors were used to adjust the oral toxicity criteria where available. Most of these values were derived from data presented in ATSDR toxicological profile documents, one value was provided by ECAO, and one value was obtained from IRIS. For chemicals for which sufficient information was

lacking, a default factor of 1.0 was assumed (that is, oral toxicity criteria were not changed). An absolute oral absorption factor of 1.0 is expected to be reasonable for volatile organics since they are likely to be readily absorbed from the gastrointestinal tract.

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FIGURES

(1) (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13) (14) (15) (16) (17) (18) (19) (20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33) (34) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (48) (49) (50) (51) (52) (53) (54) (55) (56) (57) (58) (59) (60) (61) (62) (63) (64) (65) (66) (67) (68) (69) (70) (71) (72) (73) (74) (75) (76) (77) (78) (79) (80) (81) (82) (83) (84) (85) (86) (87) (88) (89) (90) (91) (92) (93) (94) (95) (96) (97) (98) (99) (100)

Figure 1-1
SITE LOCATION MAP

Developed from the Antioch, Illinois 7 1/2 Minute U.S.G.S. Topographic
Quadrangle Map, dated 1960, Photorevised 1972

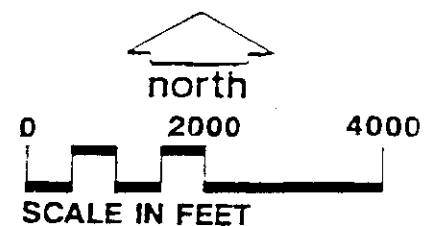
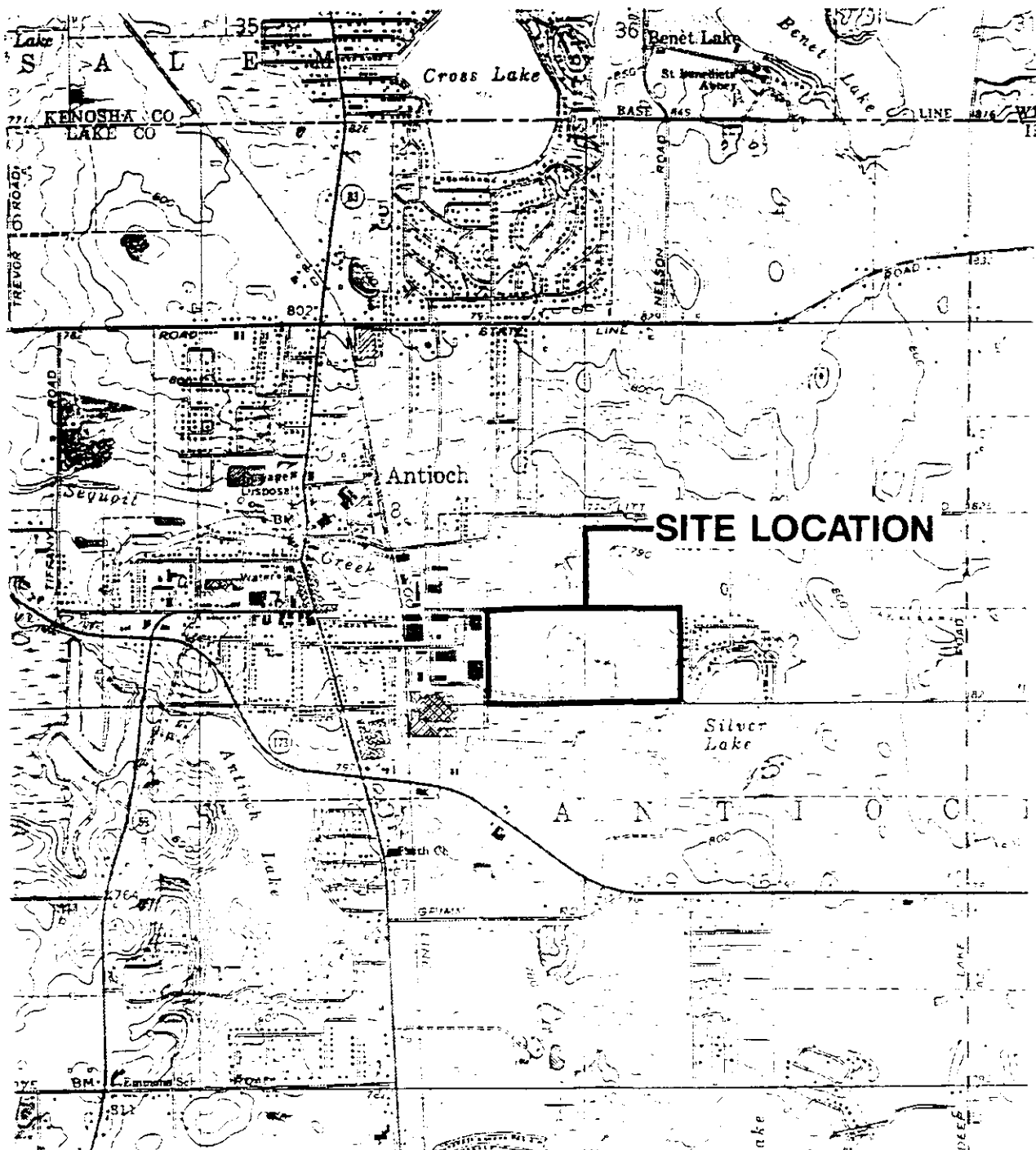
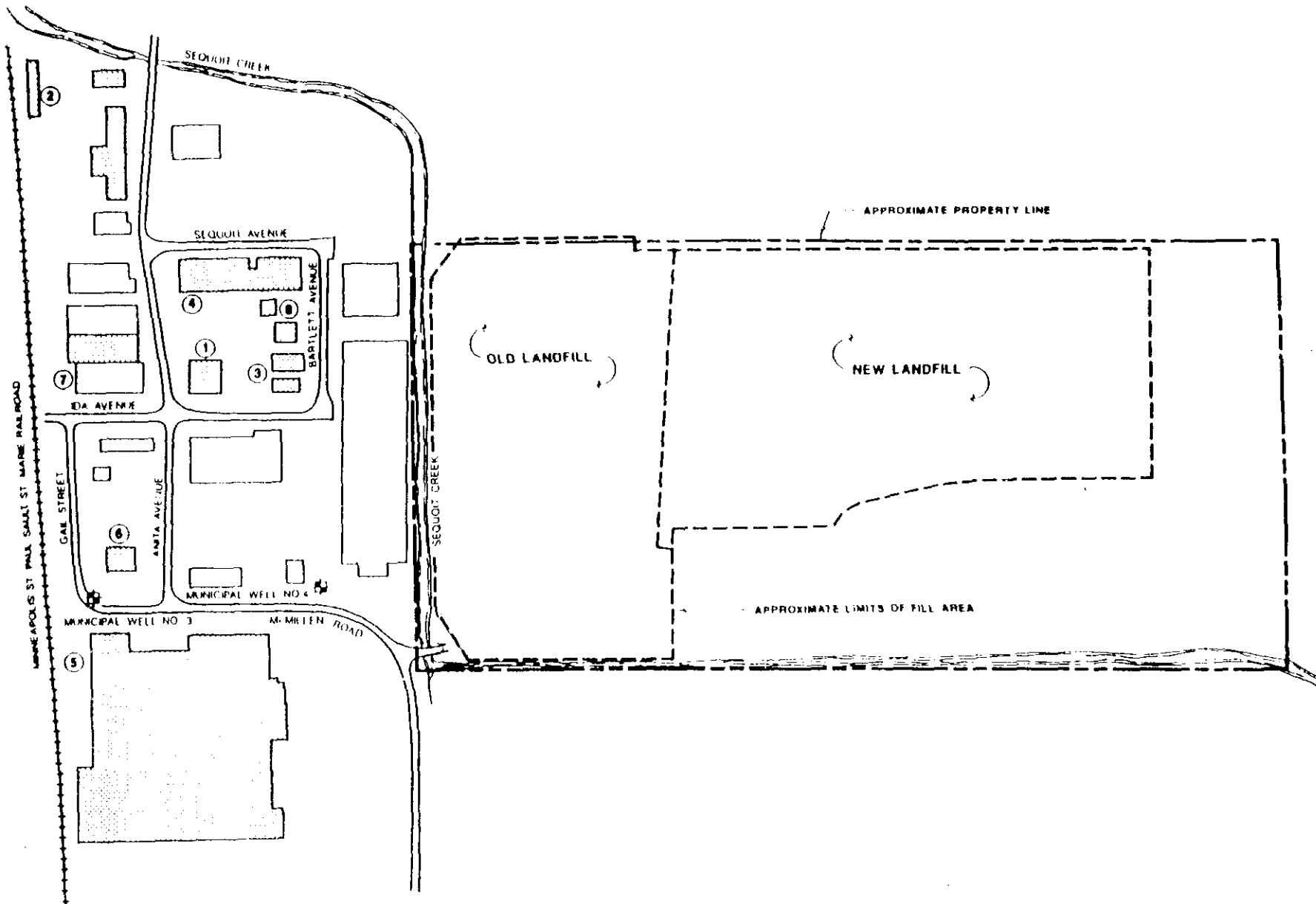


Figure 1-2

HOD LANDFILL PROPERTY LINE MAP

Developed from Environmental Audit for Sequoit Acres Industrial Park by Patrick Engineering Inc., Dated 1989



TABLES

TABLE E-1
SUMMARY OF RISK ASSESSMENT RESULTS
H.O.D. LANDFILL

EXPOSURE PATHWAY	RME EXCESS LIFETIME CANCER RISK	PREDOMINANT CHEMICALS (a)	RME HAZARD INDEX	PREDOMINANT CHEMICALS (b)
CHILD/TEENAGE SITE TRESPASSER				
Incidental surface soil ingestion	4E-09	NA	<1 (7E-05)	NA
Dermal absorption from surface soil	5E-09	NA	<1 (1E-04)	NA
Dermal contact with surface water	NE	NA	<1 (5E-03)	NA
Incidental sediment ingestion	1E-08	NA	<1 (2E-04)	NA
Dermal absorption from sediment	4E-11	NA	<1 (1E-05)	NA
Direct contact with carcinogenic PAHs				
Surface soil	Cancer risk not likely	NA	NA	NA
Sediment	Cancer risk not likely	NA	NA	NA
NEARBY ADULT RESIDENT				
Ingestion of groundwater				
Off-site surficial sand	5E-05	Beryllium	>1 (6)	Manganese
Off-site deep sand and gravel	8E-04	Vinyl Chloride	<1 (9E-01)	NA
Municipal wells	9E-05	Arsenic	<1 (5E-01)	NA
Private wells	NE	NA	<1 (8E-02)	NA
NEARBY ADULT RESIDENT (Cont.)				
Inhalation of volatiles while showering				
Off-site deep sand and gravel	6E-05	Vinyl Chloride	NE	NA
Municipal wells	5E-07	NA	<1 (2E-03)	NA
Dermal absorption while showering				
Off-site surficial sand	2E-05	Beryllium	<1 (2E-01)	NA
Off-site deep sand and gravel	3E-05	Vinyl Chloride	<1 (4E-02)	NA
Municipal wells	2E-07	NA	<1 (7E-03)	NA
Private wells	NE	NA	<1 (4E-04)	NA
Inhalation of volatiles from ambient air	5E-07	NA	<1 (3E-04)	NA

NA = Not applicable.

NE = Not evaluated since chemicals relevant for this health endpoint were not selected or detected in this data grouping.

(a) Predominant chemicals are those with RME cancer risk greater than 1E-06 (1 in 1,000,000).

(b) Predominant chemicals are those with RME hazard quotients greater than 1.

TABLE 2-1

H.O.D. LANDFILL, ANTIOCH, ILLINOIS
REMEDIAL INVESTIGATION DATA GROUPING FOR RISK ASSESSMENT

ENVIRONMENTAL MEDIUM	DATA GROUPING			
GROUNDWATER	ON SITE		OFF SITE	
	Surficial Sand Aquifer	Deep Sand and Gravel Aquifer	Surficial Sand Aquifer	Deep Sand and Gravel Aquifer
	G11S (a,c)	Downgradient	Downgradient	Downgradient
	US04S (c)	G11D (b,c)	US03I (b,c)	US03D (c)
	US06I (b,c)	US04D (c)	US03S (c)	W03D(c)
	US06S (c)	US06D (c)	W03SB (c)	Upgradient
	W05S (c)	Upgradient	W04S (c)	US01D (c)
	W06S (c)	W07D (c)	Upgradient	
			US01S (c)	
	LEACHATE	ON SITE		
LP01				
LP06				
LP08				
LP11				
MHE (manhole east)				
LANDFILL GAS	ON SITE			
	LP01			
	LP06			
	LP07			
	LP08			
	LP11			
SURFACE SOIL	ON SITE			
	SU01			
	SU02			
	SU03			
	SU04			
	SU05			
SURFACE WATER	DOWNSTREAM	UPSTREAM		
	S201 (c)	S101 (c)		
	S301 (c)	S501 (d)		
	PSG1 (d)	S401 (d)		
	PSG2 (d)	S601 (d)		
SEDIMENT	DOWNSTREAM	UPSTREAM		
	S201 (d)	S101 (d)		
	S301 (d)	S401 (d)		
	PSG1 (d)	S501 (d)		
	PSG2 (d)	S601 (d)		
	MUNICIPAL WELLS	VW03 (c)		
VW04 (d)				
VW05 (c)				
PRIVATE WELLS (Silver Lake Area)	PW01			
	PW02			
	PW03			
	PW05			

- (a) This well is actually screened in sand but not in the surficial sand aquifer, however, it is grouped here for risk assessment purposes.
- (b) These wells are actually screened in clay, however, they are grouped here for risk assessment purposes.
- (c) Sampled in both May 1993 and March 1994.

TABLE 2-2

SUMMARY OF CHEMICALS DETECTED IN ON-SITE SURFACE SOIL
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/kg for organics and mg/kg for inorganics]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations	Range of Background Concentrations (e)
Organics:						
Acenaphthene	2 / 5	5	350	410 - 430	120 - 1,000	---
Acetone	4 / 5	5	39	12	8.0 - 140	---
Anthracene	1 / 5	1	NA	NU	46	---
Benzene	1 / 5	4	6.5	12 - 13	7.0	---
Benzo(b)fluoranthene	1 / 5	1	NA	NU	110	---
Carbazole	1 / 5	1	NA	NU	130	---
Carbon disulfide	1 / 5	1	NA	NU	6.0	---
4,4'-DDD	1 / 5	5	2.6	4.1 - 4.5	4.3	---
Dibenzofuran	2 / 5	5	260	410 - 430	59 - 620	---
1,4-Dichlorobenzene	1 / 5	1	NA	NU	130	---
Ethylbenzene	2 / 5	5	57	12 - 39	12 - 240	---
Fluoranthene	4 / 5	4	100	NU	59 - 160	---
Fluorene	2 / 5	5	240	410 - 430	68 - 500	---
bis(2-Ethylhexyl)phthalate	5 / 5	5	2,800	NU	160 - 9,600	---
Methylene Chloride	4 / 5	5	280	33	48 - 700	---
2-Methylnaphthalene	2 / 5	5	220	410 - 430	61 - 390	---
Naphthalene	2 / 5	5	320	410 - 430	320 - 630	---
Phenanthrene	5 / 5	5	160	NU	51 - 250	---
Pyrene	4 / 5	4	73	NU	52 - 110	---
Toluene	3 / 5	5	18	12 - 13	3.0 - 55	---
Xylenes (total)	2 / 5	5	70	12 - 39	37 - 280	---
Inorganics:						
Aluminum	5 / 5	5	7,500	NU	6,300 - 8,700	30,000
Arsenic	5 / 5	5	3.7	NU	1.9 - 5.2	4.7 - 8.4
Barium	5 / 5	5	36	NU	25 - 54	500 - 700
Beryllium	5 / 5	5	0.60	NU	0.54 - 0.74	---
Cadmium	2 / 5	5	0.69	0.74 - 0.81	1.0 - 1.3	---
Calcium	5 / 5	5	66,000	NU	22,000 - 88,000	5,500 - 8,600
Chromium (total)	5 / 5	5	14	NU	10 - 16	50
Cobalt	5 / 5	5	8.1	NU	4.1 - 11	10 - 15
Copper	5 / 5	5	19	NU	15 - 26	10 - 30
Iron	5 / 5	5	18,000	NU	9,200 - 24,000	10,000 - 30,000
Lead	5 / 5	5	13	NU	12 - 14	10 - 70
Magnesium	5 / 5	5	31,000	NU	11,000 - 41,000	2,000 - 7,000
Manganese	5 / 5	5	450	NU	89 - 740	300 - 500
Nickel	5 / 5	5	17	NU	11 - 23	15 - 30
Potassium	5 / 5	5	1,600	NU	1,200 - 1,900	18,000 - 29,000
Sodium	5 / 5	5	210	NU	66 - 520	7,000
Vanadium	5 / 5	5	21	NU	15 - 27	30 - 70
Zinc	5 / 5	5	52	NU	44 - 75	50 - 100

NA = Not applicable; since there was only one value.

NU = Not used; detection limits were not used to calculate the mean because the chemical was detected in all samples, or because detection limits were considered to be high (i.e., one-half of the detection limit for non-detect samples exceeded the maximum detected concentration) and were excluded from the data set.

(a) Surface soil samples were collected during one phase of sampling (May 1993). On-site surface soil consists of samples SU01, SU02, SU03, SU04 (with duplicate sample), and SU05.

(b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.

(c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean.

(d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.

(e) Regional background levels from Cook County, Illinois and Kenosha and Green Counties, Wisconsin (Boerngen and Shacklette 1981).

TABLE 2-3

SUMMARY OF CHEMICALS DETECTED IN SURFACE WATER
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/L]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations	Upstream (Background) Concentrations
Organics:						
2-Hexanone	1 / 6	1	NA	NU	3.0	ND (<10)
4-Methyl-2-pentanone	1 / 6	1	NA	NU	2.0	ND (<10)
Inorganics:						
Aluminum	2 / 6	4	81	140 - 175	73 - 107	113
Antimony	1 / 6	4	14	24 - 27.6	20	ND (< 24)
Barium	6 / 6	4	21	NU	18 - 23	17 - 22
Calcium	6 / 6	4	48,000	NU	47,000 - 52,000	42,000 - 53,000
Copper	1 / 6	4	1.1	1.9 - 2.0	2.1	2.3
Iron	4 / 6	4	190	125 - 192	190 - 420	118
Lead	1 / 6	4	0.91	1.6 - 2.0	1.5	ND (< 2.0)
Magnesium	6 / 6	4	25,000	NU	25,000 - 26,000	24,000 - 26,000
Manganese	6 / 6	4	59	NU	38 - 105	25 - 130
Potassium	6 / 6	4	2,500	NU	2,000 - 2,800	2,200 - 2,600
Sodium	6 / 6	4	32,000	NU	26,000 - 35,000	24,000 - 35,000

NA = Not applicable; since there was only one value.

NU = Not used; detection limits were not used to calculate the mean because the chemical was detected in all samples, or because detection limits were considered to be high (i.e., one-half of the detection limit for non-detect samples exceeded the maximum detected concentration) and were excluded from the data set.

ND = Not detected; detection limit is presented in parentheses.

(a) Surface water locations S101, S201, and S301 were sampled during two sampling phases (May 1993 and March 1994); locations S401, S501, S601, PSG1 and PSG2 were sampled during one phase (March 1994) only. Duplicate samples were taken at locations S301 and S401. Locations S101, S401, S501, and S601 were considered to be upstream (background) samples.

(b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.

(c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean, and because samples that were collected from the same location during separate sampling phases were averaged before calculating the mean.

(d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.

TABLE 2-4

SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/kg for organics and mg/kg for inorganics]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations	Upstream (Background) Concentrations
Organics:						
Benzo(a)anthracene	1 / 4	1	NA	NU	250	ND (490 - 1,100)
Benzo(a)pyrene	1 / 4	1	NA	NU	290	ND (490 - 1,100)
Benzo(b)fluoranthene	1 / 4	1	NA	NU	430	ND (490 - 1,100)
Chrysene	1 / 4	1	NA	NU	300	ND (490 - 1,100)
bis(2-Ethylhexyl)phthalate	2 / 4	4	1,200	2,100 - 2,500	940 - 1,500	ND (490 - 1,100)
Fluoranthene	2 / 4	2	530	NU	380 - 680	ND (490 - 1,100)
Phenanthrene	1 / 4	1	NA	NU	310	ND (490 - 1,100)
Pyrene	2 / 4	2	470	NU	370 - 580	ND (490 - 1,100)
Inorganics:						
Aluminum	4 / 4	4	6,400	NU	4,620 - 9,260	1,740 - 9,340
Arsenic	4 / 4	4	6.2	NU	5.5 - 7.2	2.4 - 4.2
Barium	4 / 4	4	80	NU	53.7 - 105	12.9 - 102.9
Beryllium	4 / 4	4	0.4	NU	0.3 - 0.5	0.3 - 0.5
Cadmium	2 / 4	4	1.6	2.3 - 2.7	1.7 - 2.0	1.0 - 1.3
Calcium	4 / 4	4	42,000	NU	19,700 - 77,100	2,490 - 13,600
Chromium (total)	4 / 4	4	11	NU	9 - 14.6	3.4 - 15.1
Cobalt	2 / 4	4	4.5	4.9 - 5.8	5.7 - 6.8	3.3 - 5.6
Copper	4 / 4	4	20	NU	17 - 25.1	4.0 - 20.4
Cyanide	2 / 4	4	0.22	0.23 - 0.37	0.17 - 0.40	0.16 - 0.22
Iron	4 / 4	4	14,000	NU	7,830 - 17,500	2,400 - 14,200
Lead	4 / 4	4	24	NU	18.1 - 30.4	13.9 - 22.5
Magnesium	4 / 4	4	16,000	NU	5,320 - 37,000	1,060 - 5,320
Manganese	4 / 4	4	460	NU	285 - 565	51.3 - 457
Mercury	2 / 4	4	0.15	0.18 - 0.25	0.10 - 0.30	0.06 - 0.19
Nickel	4 / 4	4	16	NU	13.3 - 19.1	3.0 - 17.7
Potassium	4 / 4	4	740	NU	479 - 976	171 - 982
Sodium	4 / 4	4	380	NU	207 - 527	96.9 - 304.5
Thallium	4 / 4	4	2.7	NU	1.3 - 3.9	ND (0.76 - 1.75)
Vanadium	4 / 4	4	20	NU	14.7 - 25.7	5.0 - 29.8
Zinc	4 / 4	4	62	NU	26.6 - 93.1	16 - 44.9

NA = Not applicable; since there was only one value.

U = Not used; detection limits were not used to calculate the mean because the chemical was detected in all samples, or because detection limits were considered to be high (i.e., one-half of the detection limit for non-detect samples exceeded the maximum detected concentration) and were excluded from the data set.

ND = Not detected; detection limit is presented in parentheses.

(a) Sediment locations S101, S201, S301, S401, S501, S601, PSG1, and PSG2 were sampled during one sampling phase only (March 1994). A duplicate sample was taken at location S401. Locations S101, S401, S501, and S601 were considered to be upstream (background) samples.

(b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.

(c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean.

(d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.

TABLE 2-5

SUMMARY OF CHEMICALS DETECTED IN ON-SITE LEACHATE
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/L]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations
Organics:					
Acetone	5 / 5	5	4,600	NU	78 - 19,000
Aroclor-1016	1 / 5	5	1.5	1.0 - 1.1	5.5
Benzene	2 / 5	2	17	NU	13 - 22
2-Butanone	5 / 5	5	3,900	NU	110 - 12,000
Chloroethane	1 / 5	2	25	10	46
1,4-Dichlorobenzene	2 / 5	3	10	10	5.0 - 20
1,1-Dichloroethane	1 / 5	2	13	25	13
1,2-Dichloroethane	1 / 5	2	17	25	22
1,1-Dichloroethene	1 / 5	1	NA	NU	5.0
1,2-Dichloroethene (total)	3 / 5	4	100	250	16 - 190
1,2-Dichloropropane	1 / 5	2	23	38	28
Diethylphthalate	2 / 5	5	14	10 - 52	4 - 32
2,4-Dimethylphenol	5 / 5	5	8.9	NU	3 - 20
Ethylbenzene	2 / 5	4	77	10 - 250	49 - 130
bis(2-Ethylhexyl)phthalate	1 / 5	5	21	10 - 52	42
2-Hexanone	1 / 5	2	9.5	10	14
4-Methyl-2-pentanone	4 / 5	5	190	500	22 - 450
Methylene Chloride	3 / 5	3	91	NU	44 - 170
2-Methylphenol	1 / 5	3	8.7	10	16
4-Methylphenol	5 / 5	5	860	NU	5 - 2,200
Naphthalene	5 / 5	5	17	10	6 - 30
Phenol	5 / 5	5	220	NU	5 - 840
Tetrachloroethene	2 / 5	2	9.0	NU	9.0
Toluene	5 / 5	5	330	NU	62 - 740
Trichloroethene	1 / 5	2	13	25	14
Vinyl Chloride	1 / 5	2	15	25	18
Xylenes (total)	4 / 5	4	160	NU	41 - 330
Inorganics:					
Aluminum	5 / 5	5	46,000	NU	150 - 140,000
Arsenic	5 / 5	5	31	NU	4.1 - 51
Barium	5 / 5	5	810	NU	260 - 1,600
Beryllium	4 / 5	5	3.3	1.0	1.2 - 8.3
Cadmium	4 / 5	5	19	3.0	5.6 - 45
Calcium	5 / 5	5	380,000	NU	90,000 - 930,000
Chromium (total)	5 / 5	5	110	NU	9.9 - 270
Cobalt	5 / 5	5	46	NU	8.1 - 120
Copper	4 / 5	5	190	9.4	34 - 480
Cyanide	1 / 5	5	10	1.4 - 16	38
Iron	5 / 5	5	140,000	NU	7,900 - 380,000
Lead	5 / 5	5	540	NU	6.2 - 1,900
Magnesium	5 / 5	5	310,000	NU	140,000 - 570,000
Manganese	5 / 5	5	2,000	NU	76 - 5,600
Mercury	3 / 5	5	0.76	0.10	1.1 - 1.3
Nickel	5 / 5	5	170	NU	22 - 370
Potassium	5 / 5	5	300,000	NU	82,000 - 510,000
Silver	2 / 5	5	3.9	3.0	7.0 - 8.2
Sodium	5 / 5	5	890,000	NU	240,000 - 1,500,000
Thallium	3 / 5	4	1.8	2.0	2.0 - 2.2
Vanadium	5 / 5	5	85	NU	2.4 - 250
Zinc	1 / 5	5	1,700	630 - 4,500	4,700

NA = Not applicable; since there was only one value.

NU = Not used; detection limits were not used to calculate the mean because the chemical was detected in all samples, or because detection limits were considered to be high (i.e., one-half of the detection limit for non-detect samples exceeded the maximum detected concentration) and were excluded from the data set.

(a) Leachate samples were collected during one phase of sampling (May 1993). On-site leachate samples were collected from locations LP01 (with duplicate sample), LP06, LP08, LP11, and MHE.

(b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.

(c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean.

(d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.

TABLE 2-6
SUMMARY OF CHEMICALS DETECTED IN ON-SITE GROUNDWATER
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/L]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations
Surficial Sand Aquifer (e)					
Organics:					
Carbon disulfide	2 / 12	6	5.7	10	0.80 - 18
1,2-Dichloroethene (total)	3 / 12	6	11	10	2.0 - 44
Trichloroethene	2 / 12	1	1.5	NU	1.0 - 2.0
Vinyl chloride	1 / 12	6	6.2	10	19
Inorganics:					
Arsenic	1 / 5	5	3.1	3.0	9.5
Barium	5 / 5	5	110	NU	54 - 180
Calcium	5 / 5	5	160,000	NU	51,000 - 350,000
Chromium (total)	1 / 5	5	2.1	3.0	4.4
Iron	4 / 5	5	2,300	39	2,500 - 3,600
Magnesium	5 / 5	5	60,000	NU	40,000 - 130,000
Manganese	5 / 5	5	320	NU	20 - 750
Potassium	5 / 5	5	5,900	NU	1,200 - 18,000
Sodium	5 / 5	5	34,000	NU	17,000 - 56,000
Deep Sand and Gravel Aquifer (f)					
UPGRADIENT					
Inorganics:					
Barium	1 / 1	1	NA	NU	74
Calcium	1 / 1	1	NA	NU	37,000
Magnesium	1 / 1	1	NA	NU	22,000
Manganese	1 / 1	1	NA	NU	53
Potassium	1 / 1	1	NA	NU	1,600
Sodium	1 / 1	1	NA	NU	57,000
DOWNGRADIENT					
Inorganics:					
Arsenic	1 / 3	3	2.0	3.0	3.1
Barium	3 / 3	3	140	NU	53 - 280
Cadmium	1 / 3	3	2.9	3.0	5.6
Calcium	3 / 3	3	67,000	NU	42,000 - 110,000
Chromium (total)	1 / 3	3	2.2	3.0	3.5
Iron	2 / 3	3	330	64	120 - 850
Magnesium	3 / 3	3	50,000	NU	24,000 - 99,000
Manganese	3 / 3	3	27	NU	17 - 32
Potassium	3 / 3	3	2,200	NU	1,600 - 3,100
Sodium	3 / 3	3	43,000	NU	34,000 - 50,000
Thallium	1 / 3	3	1.4	2.0	2.1

NA = Not applicable; since there was only one value.

NU = Not used; detection limits were not used to calculate the mean because the chemical was detected in all samples, or because detection limits were considered to be high (i.e., one-half of the detection limit for non-detect samples exceeded the maximum detected concentration) and were excluded from the data set.

- (a) Each groundwater monitoring well location listed below (see footnotes "e" and "f") was sampled during two sampling phases (May-June 1993 and March 1994); however, during the second sampling phase, samples were analyzed for volatile organic compounds only.
- (b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.
- (c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean, or, for organics, because samples that were collected from the same location during separate sampling phases were averaged before calculating the mean.
- (d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.
- (e) Consists of samples taken from the following on-site surficial sand aquifer monitoring wells: G11S, US04S, US06I, US06S (with duplicate sample), W05S, and W06S (with duplicate sample).
- (f) Consists of samples taken from the on-site deep sand and gravel aquifer monitoring wells. The upgradient classification applies to monitoring well W07D. Downgradient wells include monitoring wells G11D, US04D (with duplicate sample), and US06D.

TABLE 2-7

SUMMARY OF CHEMICALS DETECTED IN OFF-SITE GROUNDWATER
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/L]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations
Surficial Sand Aquifer (e)					

UPGRADIENT					
=====					
Inorganics:					
Barium	1 / 1	1	NA	NU	35
Calcium	1 / 1	1	NA	NU	84,000
Iron	1 / 1	1	NA	NU	810
Magnesium	1 / 1	1	NA	NU	39,000
Manganese	1 / 1	1	NA	NU	260
Sodium	1 / 1	1	NA	NU	21,000
Zinc	1 / 1	1	NA	NU	420
DOWNGRADIENT					
=====					
Inorganics:					
Arsenic	2 / 4	4	3.0	3.0	2.8 - 6.3
Barium	4 / 4	4	140	NU	41 - 360
Beryllium	1 / 4	4	0.63	1.0 - 1.1	0.95
Cadmium	1 / 4	4	1.8	3.0	2.6
Calcium	4 / 4	4	100,000	NU	46,000 - 160,000
Chromium (total)	1 / 4	4	1.9	3.0	3.0
Cobalt	1 / 4	4	3.1	4.0	6.6
Iron	3 / 4	4	630	20	220 - 1,200
Magnesium	4 / 4	4	40,000	NU	30,000 - 55,000
Manganese	4 / 4	4	320	NU	40 - 1,100
Nickel	2 / 4	4	4.1	5.0	5.5 - 6.0
Potassium	4 / 4	4	5,100	NU	1,700 - 14,000
Sodium	4 / 4	4	63,000	NU	36,000 - 99,000
Zinc	2 / 4	4	230	10 - 510	290 - 350
Deep Sand and Gravel Aquifer (f)					

UPGRADIENT					
=====					
Inorganics:					
Barium	1 / 1	1	NA	NU	90
Calcium	1 / 1	1	NA	NU	59,000
Iron	1 / 1	1	NA	NU	660
Magnesium	1 / 1	1	NA	NU	42,000
Manganese	1 / 1	1	NA	NU	59
Potassium	1 / 1	1	NA	NU	1,200
Sodium	1 / 1	1	NA	NU	25,000
DOWNGRADIENT					
=====					
Organics:					
1,2-Dichloroethene (total)	2 / 4	2	9.8	10	11 - 18
Vinyl chloride	2 / 4	2	18	10	28 - 35
Inorganics:					
Barium	2 / 2	2	150	NU	130 - 160
Calcium	2 / 2	2	110,000	NU	97,000 - 120,000
Chromium (total)	1 / 2	2	2.9	3.0	4.3
Iron	2 / 2	2	1,600	NU	710 - 2,400
Magnesium	2 / 2	2	54,000	NU	46,000 - 63,000
Manganese	2 / 2	2	92	NU	42 - 140
Nickel	1 / 2	2	3.9	5.0	5.2
Potassium	2 / 2	2	2,600	NU	2,580 - 2,610
Sodium	2 / 2	2	65,000	NU	63,000 - 68,000
Zinc	1 / 2	2	280	470	310

See footnotes on following page.

TABLE 2-7 (continued)

SUMMARY OF CHEMICALS DETECTED IN OFF-SITE GROUNDWATER
AT THE H.O.D. LANDFILL SITE

[Concentrations reported in ug/L]

NA = Not applicable; since there was only one value

NU = Not used; detection limits were not used to calculate the mean because the chemical was detected in all samples, or because detection limits were considered to be high (i.e., one-half of the detection limit for non-detect samples exceeded the maximum detected concentration) and were excluded from the data set.

- (a) Each groundwater monitoring well location listed below (see footnotes "e" and "f") was sampled during two sampling phases (May-June 1993 and March 1994); however, during the second sampling phase, samples were analyzed for volatile organic compounds only.
- (b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.
- (c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean, or, for organics, because samples that were collected from the same location during separate sampling phases were averaged before calculating the mean.
- (d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.
- (e) Consists of samples taken from off-site surficial sand aquifer monitoring wells. Monitoring well US01S (with duplicate sample) was considered to be upgradient to the site. Downgradient wells include US03I, US03S, W03SB, and W04S (with duplicate sample).
- (f) Consists of samples taken from off-site deep sand and gravel aquifer monitoring wells. The upgradient classification applies to monitoring well US01D. Downgradient wells include monitoring wells US03D and W03D.

TABLE 2-8

SUMMARY OF CHEMICALS DETECTED IN PRIVATE AND MUNICIPAL WELLS
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/L]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations
Private Wells (e)					
Organics					
2-Methylphenol	1 / 4	1	NA	NU	0.90
Inorganics					
Aluminum	1 / 4	4	38	50	75
Barium	4 / 4	4	140	NU	61 - 260
Calcium	4 / 4	4	43,000	NU	26,000 - 83,000
Chromium (total)	4 / 4	4	0.53	NU	0.20 - 0.89
Cobalt	1 / 4	4	6.3	10	10
Copper	1 / 4	4	10	10	26
Iron	4 / 4	4	1,100	NU	160 - 3,100
Lead	1 / 4	4	2.5	3.0	5.5
Magnesium	4 / 4	4	24,000	NU	15,000 - 48,000
Manganese	1 / 4	4	10	10	26
Potassium	4 / 4	4	1,700	NU	1,100 - 2,300
Sodium	4 / 4	4	56,000	NU	53,000 - 61,000
Vanadium	1 / 4	4	1.4	2.0	2.7
Zinc	3 / 4	4	180	10	48 - 610
Municipal Wells (f)					
Organics:					
Acetone	2 / 2	2	8.5	NU	6.0 - 11
Carbon disulfide	1 / 5	3	0.52	1.0	0.60
4-Chloroaniline	1 / 2	1	NA	NU	0.70
Chloroform	1 / 5	1	NA	NU	0.50
1,2-Dichloroethane	2 / 5	3	0.58	1.0	0.7 - 0.8
cis-1,2-Dichloroethene	1 / 5	3	0.53	1.0	0.60
2-Methylphenol	1 / 2	1	NA	NU	0.50
Inorganics:					
Aluminum	1 / 2	2	33	50	40
Arsenic	2 / 2	2	3.2	NU	2.1 - 4.3
Barium	2 / 2	2	75	NU	59 - 91
Calcium	2 / 2	2	48,000	NU	41,000 - 55,000
Chromium (total)	1 / 2	2	0.17	0.20	0.25
Iron	2 / 2	2	870	NU	650 - 1,100
Magnesium	2 / 2	2	33,000	NU	30,000 - 37,000
Manganese	1 / 2	2	7.5	10	10
Potassium	2 / 2	2	1,500	NU	1,500 - 1,600
Sodium	2 / 2	2	35,000	NU	29,000 - 41,000
Zinc	1 / 2	2	15	10	25

NA = Not applicable, since there was only one value.

NU = Not used; chemical was detected in all samples, or non-detect samples were excluded from the data set due to high detection limits (one-half the detection limit was greater than the maximum detected concentration).

- (a) Private wells were sampled during one sampling phase (June-July 1993). Municipal wells VW03 and VW05 were sampled during two sampling phases (June 1993 and March 1994); while municipal well VW04 was sampled during the second sampling phase only (March 1994). Samples collected in March 1994 were analyzed for volatile organic compounds.
- (a) The number of samples in which the chemical was detected divided by the total number of samples analyzed.
- (b) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean, or, for organics, because samples that were collected from the same location during separate sampling phases were averaged before calculating the mean.
- (c) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.
- (d) Consists of samples taken from private wells: PW01, PW02, PW03, and PW05.
- (e) Consists of samples taken from the following municipal wells: VW03, VW04 (with duplicate sample), and VW05 (with duplicate sample).

TABLE 2-9

SUMMARY OF CHEMICALS DETECTED IN ON-SITE LANDFILL GAS
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ppb (v/v) vapor]

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detection Limits	Range of Detected Concentrations
Organics:					
Acetone	3 / 5	5	4,100	20 - 1,500	730 - 15,000
Benzene	5 / 5	5	550	NU	10 - 970
2-Butanone	5 / 5	5	5,900	NU	21 - 22,000
Carbon disulfide	1 / 5	3	400	20 - 1,000	690
Chlorobenzene	2 / 5	5	1,000	5 - 500	180 - 4,500
Chloroethane	2 / 5	5	450	750 - 1,000	47 - 810
Chloromethane	1 / 5	4	290	5 - 500	720
1,1-Dichloroethane	2 / 5	5	220	5 - 500	140 - 540
1,1-Dichloroethene	1 / 5	5	170	4 - 400	480
cis-1,2-Dichloroethene	5 / 5	5	2,000	NU	6.3 - 5,400
Ethylbenzene	5 / 5	5	5,600	NU	34 - 11,000
Methylene Chloride	3 / 5	5	320	800	95 - 460
Tetrachloroethene	4 / 5	5	1,700	6.0	270 - 4,400
Toluene	5 / 5	5	30,000	NU	540 - 66,000
Trichloroethene	4 / 5	5	850	5.0	160 - 2,500
1,2,4-Trimethylbenzene	4 / 5	5	820	6.0	360 - 2,100
1,3,5-Trimethylbenzene	3 / 5	5	360	5 - 380	200 - 910
Vinyl Chloride	4 / 5	5	8,000	5.0	1,200 - 21,000
Xylenes (total)	5 / 5	5	14,000	NU	52 - 30,000

NU = Not applicable; chemical was detected in all samples, or non-detect samples were excluded from the data set due to high detection limits (one-half the detection limit was greater than the maximum detected concentration).

(a) The on-site group consists of samples LGLP01, LGLP06, LGLP07, LGLP08, LGLP11, and the duplicate of LGLP11.

(b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.

(c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean.

(d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.

TABLE 2-10
SUMMARY OF CHEMICALS DETECTED IN FIELD AND TRIP BLANKS
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/L]

Chemical	Frequency of Detection (b)	Range of Detected Concentrations
SURFACE WATER		
Field Blank (c)		
Organics:		
Acetone	1 / 3	30
Methylene Chloride	1 / 3	5.0
Toluene	1 / 3	1.0
Inorganics:		
Calcium	1 / 3	1,260
Iron	3 / 3	20.5 - 35.2
Magnesium	1 / 3	25.6
Sodium	2 / 3	304 - 312
Zinc	3 / 3	6.1 - 154
Trip Blank (d)		
Organics:		
Methylene chloride	1 / 1	6.0
GROUNDWATER		
Field Blank (e)		
Organics:		
Acetone	3 / 6	7.0 - 38
Di-n-butylphthalate	3 / 3	2.0 - 3.0
Toluene	1 / 6	0.9
Inorganics:		
Aluminum	2 / 3	59.4 - 59.5
Calcium	3 / 3	2,610 - 5,840
Lead	2 / 3	2.4 - 4.1
Magnesium	2 / 3	51.3 - 56.9
Sodium	1 / 3	619
Zinc	3 / 3	241 - 678
Trip Blank (f)		
Organics:		
Acetone	3 / 8	4.0 - 7.0
Methylene chloride	1 / 8	2.0
PRIVATE WELLS		
Field Blank (g)		
Organics:		
Acetone	1 / 1	6.0
Bromodichloromethane	1 / 1	0.9
Chloroform	1 / 1	11
bis(2-Ethylhexyl)phthalate	1 / 1	6.0
Methylene chloride	1 / 1	3.0
Trip Blank (h)		
Organics:		
Acetone	2 / 2	4.0
Bromodichloromethane	2 / 2	0.7 - 0.9
Chloroform	2 / 2	11 - 12
Methylene chloride	1 / 2	6.0

See footnotes on following page.

TABLE 2-10 (continued)

SUMMARY OF CHEMICALS DETECTED IN FIELD AND TRIP BLANKS
AT THE H.O.D. LANDFILL SITE (a)

[Concentrations reported in ug/L]

Chemical	Frequency of Detection (b)	Range of Detected Concentrations
MUNICIPAL WELLS		
Trip Blank (i)		

Organics:		
Methylene Chloride	1 / 1	2.0
LEACHATE		
Field Blank (j)		

Organics:		
Acetone	1 / 1	13
Di-n-butylphthalate	1 / 1	1.0
Methylene chloride	1 / 1	1.0
Inorganics:		
Aluminum	1 / 1	62
Calcium	1 / 1	6,200
Copper	1 / 1	5.2
Iron	1 / 1	23
Magnesium	1 / 1	33
Manganese	1 / 1	2.7
Sodium	1 / 1	730
Zinc	1 / 1	610
Trip Blank (k)		

Organics:		
Acetone	1 / 2	5.0
Methylene chloride	1 / 2	3.0

(a) Field and trip blank samples from all media and sampling phases are presented in this table. It should be noted that no chemicals were detected in the landfill gas trip blank, LGTB01.

(b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.

(c) Consists of surface water field blanks SWFB01-01, SWFB01-02, and SWFB02-02.

(d) Consists of surface water trip blank SWTB01-01.

(e) Consists of groundwater field blanks GWFB01-01, GWFB02-01, and GWFB03-01.

(f) Consists of groundwater trip blanks GWTB01-01, GWTB02-01, GWTB03-01, GWTB04-01, GWTB05-01, GWTB01-02, GWTB02-02, and GWTB03-02.

(g) Consists of private well field blank PWFB01-01.

(h) Consists of private well trip blanks PWTB01-01 and PWTB02-01.

(i) Consists of municipal well trip blank GWTB04-02.

(j) Consists of leachate field blank sample LCFB01-01.

(k) Consists of leachate trip blanks LCTB01-01 and LCTB02-01.

TABLE 2-11

SUMMARY OF REGIONAL BACKGROUND GROUNDWATER DATA (a)
(Concentrations in ug/liter)

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detected Concentrations
Dissolved:				
Arsenic	13/23	23	2.1	1 - 10
Barium	28/30	30	71	34 - 100
Boron	38/38	38	406	200 - 800
Cadmium	4/22	22	1.5	1 - 3
Calcium	56/56	56	35,200	3,000 - 76,000
Chloride	81/84	84	4.8	1 - 22
Copper	6/25	25	6.3	4 - 71
Lead	9/22	22	7.0	6 - 26
Magnesium	56/56	56	29,800	2,300 - 75,700
Mercury	3/21	21	41	100 - 150
Nickel	7/23	23	8.9	4 - 100
Potassium	34/34	34	1,620	910 - 5,100
Selenium	1/22	22	0.52	1
Silver	1/22	22	2.8	10
Sodium	58/58	58	42,200	9,000 - 83,000
Sulfate	71/72	72	59	2 - 242
Zinc	10/23	23	14	2 - 212
Total:				
Aluminum	1/18	18	99	1,360
Arsenic	10/18	18	2.6	1 - 26
Barium	18/18	18	64	35 - 180
Beryllium	1/34	31	0.40	1
Boron	18/18	18	340	230 - 420
Calcium	18/18	18	38,900	29,000 - 73,000
Cobalt	4/37	37	3.0	5 - 9
Copper	1/18	18	2.9	9
Iron	75/76	76	620	100 - 4,000
Lead	2/17	17	3.0	5 - 8
Magnesium	18/18	18	31,100	25,000 - 41,000
Manganese	34/47	47	13	5 - 130
Mercury	4/18	18	0.03	0.04 - 0.06
Nickel	4/18	18	3.7	6 - 14
Potassium	15/18	18	1,270	1,100 - 2,400
Selenium	1/18	17	0.53	1
Silver	2/18	18	1.9	4 - 5
Sodium	18/18	18	43,500	23,000 - 62,000
Vanadium	1/34	34	2.4	5

- (a) Data obtained from Illinois State Water Survey, Groundwater Division. All samples were obtained from Lake County, Illinois.
- (b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.
- (c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean.
- (d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.

TABLE 2-12

**SUMMARY OF REGIONAL BACKGROUND
SURFACE SOIL DATA (a)
(Concentrations in mg/kg)**

Chemical	Frequency of Detection (b)	Mean Sample Size (c)	Arithmetic Mean (d)	Range of Detected Concentrations
Arsenic	3/3	3	7.1	4.7 - 8.4
Barium	3/3	3	570	500 - 700
Calcium	3/3	3	6,700	5,500 - 8,600
Chromium (total)	3/3	3	50	50
Cobalt	3/3	3	12	10 - 15
Copper	3/3	3	17	10 - 30
Iron	3/3	3	16,700	10,000 - 30,000
Lead	3/3	3	32	10 - 70
Magnesium	3/3	3	4,000	2,000 - 7,000
Manganese	3/3	3	370	300 - 500
Nickel	3/3	3	20	15 - 30
Potassium	3/3	3	22,000	18,000 - 29,000
Vanadium	3/3	3	50	30 - 70
Zinc	3/3	3	67	50 - 100

- (a) Obtained from USGS surface soil data (Boerngen and Shacklette 1981) from Cook County, IL and Kenosha and Green Counties, WI.
- (b) The number of samples in which the chemical was detected divided by the total number of samples analyzed.
- (c) The number of samples used in calculating the mean. This number may differ from the denominator of the frequency of detection because non-detect samples with high detection limits were not included in calculating the mean.
- (d) Arithmetic mean concentrations were calculated using detected values and one-half the detection limit of non-detects.

TABLE 2-13
SELECTION OF CHEMICALS OF CONCERN IN GROUNDWATER
H.O.D. LANDFILL

Chemical	DATA GROUPING					
	ON SITE		OFF SITE		Private Wells (Silver Lake Area)	Municipal Wells
	Surficial Sand	Deep Sand/Gravel	Surficial Sand	Deep Sand/Gravel		
Aluminum	ND	ND	ND	ND	6	1
Arsenic	6	6	6	ND	ND	1
Barium	6	6	6	1	6	1
Beryllium	ND	ND	2	ND	ND	ND
Cadmium	ND	6	6	ND	ND	ND
Calcium	5	5/6	5	5	5/6	5
Chromium (total)	2	2	2	1	2	1
Cobalt	ND	ND	2	ND	4	ND
Copper	ND	ND	ND	ND	4	ND
Iron	5	5	5	5	5/6	5
Lead	ND	ND	ND	ND	6	ND
Magnesium	5	5/6	5/6	5	5/6	5
Manganese	2	2	2	1	6	1
Nickel	ND	ND	6	1	ND	ND
Potassium	5/6	5/6	5/6	5	5/6	5
Sodium	5/6	5/6	5/6	5	5	5
Thallium	ND	2	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	6	ND
Zinc	ND	ND	6	1	2	1
Carbon disulfide	3	ND	ND	ND	ND	3
4-Chloroaniline	ND	ND	ND	ND	ND	3
1,2-Dichloroethene	3	ND	ND	3	ND	3
2-Methylphenol	ND	ND	ND	ND	3	3
Trichloroethene	3	ND	ND	ND	ND	ND
Vinyl chloride	3	ND	ND	3	ND	ND
Acetone	ND	ND	ND	ND	ND	3
Chloroform	ND	ND	ND	ND	ND	3
1,2-Dichloroethane	ND	ND	ND	ND	ND	3

3 = Chemical selected for this data grouping.

ND = Not detected in this data group.

Rationale for chemical selection:

- 1 = Selected as a default because there were fewer than 3 samples in this data grouping, in accordance with telephone conference call with USEPA Region V on February 3, 1994.
- 2 = Selected because regional background data were not available for this chemical.
- 3 = All organic chemicals were selected.
- 4 = Selected because a significant difference was observed in a t-test with regional background data (at $p = 0.05$ significance level).

Rationale for chemical exclusion:

- 5 = Chemical not selected because it is an essential human nutrient.
- 6 = Chemical not selected because no significant difference was observed in a t-test with regional background groundwater data (at $p = 0.05$ significance level).

TABLE 2-14

SELECTION OF CHEMICALS OF CONCERN IN ON-SITE
SURFACE WATER, SEDIMENT, AND SOIL
H.O.D. LANDFILL

Chemical	On-Site Soil	Sequoit Creek Surface Water	Sequoit Creek Sediment
Acenaphthene	3	ND	ND
Acetone	3	ND	ND
Anthracene	3	ND	ND
Benzene	3	ND	ND
Benzo(a)anthracene	ND	ND	3
Benzo(a)pyrene	ND	ND	3
Benzo(b)fluoranthene	3	ND	3
Carbazole	3	ND	ND
Carbon disulfide	3	ND	ND
Chrysene	ND	ND	3
4,4'-DDD	3	ND	ND
Dibenzofuran	3	ND	ND
1,4-Dichlorobenzene	3	ND	ND
Ethylbenzene	3	ND	ND
Fluoranthene	3	ND	3
Fluorene	3	ND	ND
bis(2-Ethylhexyl)phthalate	3	ND	3
Methylene chloride	3	ND	ND
2-Methylnaphthalene	3	ND	ND
Naphthalene	3	ND	ND
Phenanthrene	3	ND	3
Pyrene	3	ND	3
Toluene	3	ND	ND
Xylenes (total)	3	ND	ND
2-Hexanone	ND	3	ND
4-Methyl-2-pentanone	ND	3	ND
Antimony	ND	2	ND
Aluminum	2	6	6
Arsenic	6	ND	4
Barium	6	4	6
Beryllium	2	ND	6
Cadmium	2	ND	6
Calcium	5	5/6	5
Chromium (total)	2	ND	6
Cobalt	6	ND	6
Copper	6	6	6
Cyanide	ND	ND	6
Iron	5/6	5	5/6
Lead	6	2	6
Magnesium	5	5/6	5/6
Manganese	6	6	6
Mercury	ND	ND	6
Nickel	6	ND	6
Potassium	5/6	5/6	5/6
Sodium	5	5/6	5
Thallium	ND	ND	2
Vanadium	6	ND	6
Zinc	6	ND	6

3 = Chemical selected for this data grouping.

ND = Not detected in this data grouping.

Rationale for chemical selection:

- 1 = Selected as a default because there were fewer than 3 samples in this data grouping in accordance with telephone conference call with EPA Region V on February 3, 1994.
- 2 = Selected because background data were not available for this chemical.
- 3 = All organic chemicals were selected.
- 4 = Selected because a significant difference was observed in a t-test with background data (at $p = 0.05$ significance level).

Rationale for chemical exclusion:

- 5 = Chemical not selected because it is essential human nutrient.
- 6 = Chemical not selected because no significant difference was observed in a t-test with background data (at $p = 0.05$ significance level) or significant difference was observed because background levels were significantly higher than site levels.

TABLE 3-1

ORAL TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN
AT THE HOD LANDFILL SITE

Chemical (a)	Chronic RfD (mg/kg-day) [Uncertainty Factor](b)	Target Organ/ Critical Effect (c)	RfD Source	Slope Factor (mg/kg-day) ⁻¹	Weight-of- Evidence Classification (d)	Slope Factor Source
Organics:						
Acenaphthene	6E-02 [3,000]	Liver	IRIS	--- (e)	---	IRIS
Acetone	1E-01 [1,000]	Kidney/Liver	IRIS	---	D	IRIS
Anthracene	3E-01 [3,000]	None Observed	IRIS	---	D	IRIS
Benzene	--- (f)	---	IRIS	2.9E-02	A	IRIS
Benzo(a)anthracene	---	---	---	7.3E+00 (f,g)	B2	IRIS
Benzo(a)pyrene	---	---	---	7.3E+00 (f)	B2	IRIS
Benzo(b)fluoranthene	---	---	---	7.3E+00 (f,g)	B2	IRIS
Bis(2-ethylhexyl)phthalate	2E-02 [1,000]	Liver	IRIS	1.4E-02	B2	IRIS
Carbazole	---	---	---	2E-02	B2	HEAST
Carbon disulfide	1E-01 [100]	Fetotoxicity	IRIS	---	---	---
4-Chloroaniline	4E-03 [3,000]	Spleen	IRIS	---	---	---
Chloroform	1E-02 [1,000]	Liver	IRIS	6.1E-03	B2	IRIS
Chrysene	---	---	HEAST	7.3E+00 (f,g)	B2	IRIS
4'-DDD	---	---	IRIS	2.4E-01	B2	IRIS
Dibenzofuran	3E-02 [3,000] (e,h)	Kidney	IRIS	---	D	IRIS
1,4-Dichlorobenzene	1E-01 [1,000]	Kidney	HA 1987	2.4E-02 (e)	B2	HEAST
1,2-Dichloroethane	---	---	---	9.1E-02	B2	IRIS
cis-1,2-Dichloroethene	1E-02 [3,000]	Hematology	HEAST	---	---	---
1,2-Dichloroethene (total)	9E-03 [1,000]	Liver	HEAST	---	D	IRIS
Ethylbenzene	1E-01 [1,000]	Liver/Kidney	IRIS	---	D	IRIS
Fluoranthene	4E-02 [3,000]	Kidney/Liver	IRIS	---	D	IRIS
Fluorene	4E-02 [3,000]	Hematology	IRIS	---	D	IRIS
Methylene chloride	6E-02 [100]	Liver	IRIS	7.5E-03	B2	IRIS
2-Methylnaphthalene	3E-02 [3,000] (h)	Kidney	IRIS	---	---	---
4-Methyl-2-pentanone (MIBK)	8E-02 [3,000] (e)	Liver/Kidney	HEAST	---	---	---
2-Methylphenol (o-cresol)	5E-02 [1,000]	Neurotoxicity	IRIS	---	C	IRIS
Naphthalene	3E-02 [3,000] (h,i)	Kidney	IRIS	---	D	IRIS
Phenanthrene	3E-02 [3,000] (h)	Kidney	IRIS	---	D	IRIS
Pyrene	3E-02 [3,000]	Kidney	IRIS	---	D	IRIS
Toluene	2E-01 [1,000]	Liver/Kidney	IRIS	---	D	IRIS
Trichloroethene	7.35E-03 [1,000]	Liver	HA 1987	1.1E-02	B2/C	ECAO 92
Vinyl chloride	---	---	---	1.9E+00	A	HEAST
Xylenes (total)	2E+00 [100]	CNS	IRIS	---	D	IRIS
Inorganics:						
Antimony	4E-04 [1,000]	Blood Chemistry	IRIS	---	---	---
Arsenic	3E-04 [3]	Skin	IRIS	1.75E+00 (j)	A	IRIS
Barium	7E-02 [3]	Inc. Blood Pressure	IRIS	---	---	---
Beryllium	5E-03 [100]	None Observed	IRIS	4.3E+00	B2	IRIS
Cadmium	1E-03 [10] (k)	Kidney	IRIS	---	---	IRIS
Chromium III	1E+00 [1,000]	Liver	IRIS	---	---	---
Chromium VI	5E-03 [500] (l)	CNS	IRIS	---	---	IRIS
Copper	3.7E-02 [1] (m)	GI Irritation	HEAST	---	---	---
Lead	---	CNS	IRIS	---	B2	IRIS
Manganese	5E-03 [1] (n)	CNS	IRIS	---	D	IRIS
Manganese	1.4E-01 [1] (o)	CNS	IRIS	---	---	---
Nickel	2E-02 [300]	< Body Weight	IRIS	---	---	---
Thallium	8E-05 [3,000] (p)	Liver	IRIS	---	D	IRIS
Zinc	3E-01 [3]	Blood Chemistry	IRIS	---	---	---

See footnotes on following page.

TABLE 3-1 (Continued)

ORAL TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN
AT THE HOD LANDFILL SITE

- a) The following chemicals are not presented because they lack toxicity criteria: aluminum, cobalt, and 2-hexanone.
- b) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors included the following:
 - A 10-fold factor to account for the variation in sensitivity among the members of the human population;
 - A 10-fold factor to account for the uncertainty in extrapolation from animal data to humans;
 - A 10-fold factor to account for uncertainty in extrapolation from less than chronic NOAELs to chronic NOAELs; and
 - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- c) A target organ is the organ most sensitive to a chemical's toxic effect. RfD's are based on toxic effects in the target organ. If an RfD is based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- d) EPA Weight of Evidence for Carcinogenic Effects:
 - [A] = Human carcinogen based on adequate evidence from human studies;
 - [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies;
 - [C] = Possible human carcinogen based on limited evidence from animal studies in the absence of human studies; and
 - [D] = Not classified as to human carcinogenicity.
- e) Under review by USEPA.
- f) Toxicity criteria revisions are pending.
- g) The slope factor for benzo(a)pyrene together with toxicity equivalency factors (TEFs) will be used to evaluate carcinogenic PAHs without toxicity criteria.
 - Pyrene was conservatively used as a surrogate to evaluate noncarcinogenic PAHs lacking toxicity criteria.
 - The oral RfD for naphthalene was recently withdrawn from HEAST (Supplement No.2) November 1992.
- j) A unit risk of $5E-5$ (ug/L)-1 has been proposed by the risk assessment forum and this recommendation has been scheduled for SAB review. This is equivalent to 1.75 (mg/kg-day)-1 assuming a 70 kg individual ingests 2 L of water per day.
- k) This RfD for cadmium is used to assess non-aqueous exposures.
- l) The RfD for chromium VI was conservatively used for Chromium, total.
- m) Value is the federal drinking water standard of 1.3 mg/L. This has been converted to a dose assuming that a 70 kg individual ingests 2 liters of water per day.
- n) This RfD for manganese is used to assess drinking water exposures.
- o) This RfD for manganese is used to assess non-aqueous exposures.
- p) Value based on thallium sulfate.

OTE: --- = No information available.
 IRIS = Integrated Risk Information System, August 1994.
 HEAST = Health Effects Assessment Summary Tables, Fiscal Year 1994.
 HA = Health Advisory, Office of Drinking Water
 ECAO = Environmental Criteria and Assessment Office

target Organs:
 CNS = central nervous system
 GI = gastrointestinal
 < = decrease

TABLE 3-2
INHALATION TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN
AT THE HOD LANDFILL SITE

Chemical	Chronic RfC (mg/cu.m) [Uncertainty Factor](a)	Target Organ/ Critical Effect (b)	RfC Source	Unit Risk (ug/cu.m)-1	Weight-of- Evidence Classification (c)	Unit Risk Source
Organics:						
Acetone	---	---	IRIS	---	D	IRIS
Benzene	---	---	IRIS	8.3E-06	A	IRIS
2-Butanone	1E+00 [3,000]	Fetotoxicity	IRIS	---	D	IRIS
Carbon disulfide	1E-02 [1,000]	Fetotoxicity	HEAST	---	---	---
Chlorobenzene	2E-02 [10,000]	Kidney/Liver	HEAST	---	D	IRIS
Chloroethane	1E+01 [300]	Fetotoxicity	IRIS	---	---	---
Chloroform	---	---	IRIS	2.3E-05	B2	IRIS
Chloromethane	---	---	IRIS	1.8E-06	C	HEAST
1,1-Dichloroethane	5E-01 [1,000]	Kidney	HEAST	---	C	IRIS
1,2-Dichloroethane	---	---	---	2.6E-05	B2	IRIS
1,1-Dichloroethene	---	---	IRIS	5E-05	C	IRIS
1,2-Dichloroethene	---	---	IRIS	---	D	IRIS
Ethylbenzene	1E+00 [300]	Development	IRIS	---	D	IRIS
o-Ethyl toluene	---	---	HEAST	---	---	---
o-Ethylene chloride	3E+00 [100]	Liver	HEAST	4.7E-07	B2	IRIS
Tetrachloroethene	---	---	IRIS	5.8E-07	C/B2	ECAO '92
Toluene	4E-01 [300]	CNS/Nasal	IRIS	---	D	IRIS
Trichloroethene	---	---	IRIS	1.7E-06	C/B2	ECAO '92
1,2,4-Trimethylbenzene	---	---	HEAST	---	---	---
1,3,5-Trimethylbenzene	---	---	HEAST	---	---	---
Vinyl chloride	---	---	---	8.4E-05	A	HEAST
Xylenes (total)	---	---	HEAST	---	D	IRIS

(a) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors included the following:

- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
- A 10-fold factor to account for the uncertainty in extrapolation from animal data to humans;
- A 10-fold factor to account for uncertainty in extrapolation from less than chronic NOAELs to chronic NOAELs; and
- A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.

(b) A target organ is the organ most sensitive to a chemical's toxic effect. RfD's are based on toxic effects in the target organ. If an RfD is based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

(c) EPA Weight of Evidence for Carcinogenic Effects:

- [A] = Human carcinogen based on adequate evidence from human studies;
- [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies;
- [C] = Possible human carcinogen based on limited evidence from animal studies in the absence of human studies; and
- [D] = Not classified as to human carcinogenicity.

Under review by USEPA.

(d) Chemical was reviewed by USEPA, and data was considered inadequate to derive criteria.

(f) Value was derived using methodologies not currently practiced by the RfD/RfC Workgroup.

NOTE: --- = No information available.
IRIS = Integrated Risk Information System, August 1994.
HEAST = Health Effects Assessment Summary Tables, Fiscal Year 1994.
ECAO = Environmental Criteria and Assessment Office

TABLE 3-3

EXPERIMENTAL STUDIES OF SKIN PAINTING WITH CARCINOGENIC PAHS AND INCIDENCE OF SKIN TUMORS

Study	Study Animal	Frequency of Application	PAH Applied		Total Tumor Incidence (%) (d)
			Compound (b)	Total Dose (ug/cm2) (c)	
aVoie et al. (1982) (a)	Swiss Albino CD-1 female mice	10 subdoses, 1 subdose in acetone every other day followed by promoter (TPA) in acetone 3x/week for 20 weeks	B[a]P	33	85 (e)
			B[b]F	110	80 (e)
				33	60 (e)
				11	45 (e)
			B[j]F	1,102	95 (e)
				110	55 (e)
				33	30 (e)
			B[k]F	1,102	75 (e)
				110	25 (e)
				33	5 (e)
Singham and Falk (1969)	C3H/He mice	3x/week for 50 weeks	Acetone Control		0
			B[a]P	11.03	50 (42)
				1.10	0
			BaP in decalin	0.11	0
			BaA in toluene	0.011	0
			n-dodecane + decalin (control)		0
			B[a]A	551	28 (17)
				110	9
				11.0	6
				1.10	0
Sislocki et al. (1977)	Female C57BL/6J	1x/2 weeks for 60 weeks in acetone or acetone NH4OH (1000:1)	B[a]P	3,334	100
				834	96
			Acetone control		0
Spitulnik et al. (1976)	Female C57BL/6J mice	1x/2 weeks for 60 weeks in acetone	B[a]P	3,334	92
			acetone control	25	0
Levin et al. (1976)	Female C57BL/6J mice	1x/2 weeks for 60 weeks in acetone:NH4OH (1000:1)	B[a]P	3,334	100
				834	94
			solvent control		0
Levin et al. (1977)	Female C57BL/6J mice	1x/2 weeks for 60 weeks in DMSO:acetone or acetone:NH4OH (1000:1)	B[a]P	3,334	100
				834	38-91
				167	0-4
			solvent control		0
Sabs et al. (1980) (f)	NMRI female mice	2x/week for lifetime in acetone	B[a]P	1.45 ug/cm2-day	61.1
				0.88 ug/cm2-day	68.6
				0.54 ug/cm2-day	23.5
			B[b]F	2.90 ug/cm2-day	54.1
				1.76 ug/cm2-day	14.7
				1.07 ug/cm2-day	5.3
			B[j]F	2.90 ug/cm2-day	5.3
				1.76 ug/cm2-day	2.9
				1.07 ug/cm2-day	2.6
			B[k]F	2.90 ug/cm2-day	0
				1.76 ug/cm2-day	0
				1.07 ug/cm2-day	2.6
			CP	8.57 ug/cm2-day	7.9
				2.14 ug/cm2-day	0
				0.54 ug/cm2-day	0
			IND	2.90 ug/cm2-day	0
				1.76 ug/cm2-day	0
				1.07 ug/cm2-day	2.8
			acetone control		0

(a) Initiation-promotion study, which evaluated the tumor initiating activities of several carcinogenic PAHs. This study indicates concentrations of PAHs which can interact with tumor-promoting chemicals that may be present in the mixture of chemicals at a given hazardous waste site to induce skin tumors.

(b) B[a]P = benzo(a)pyrene, B[b]F = benzo(b)fluoranthene, B[j]F = benzo(j)fluoranthene, B[k]F = benzo(k)fluoranthene, B[a]A = benzo(a)anthracene, IND = indeno(1,2,3-cd)pyrene, CP = cyclopentadieno(cd)pyrene.

(c) Assumes a surface area of 0.907 cm² (3/8 square inch).

(d) Malignant tumor incidence is presented in parentheses.

(e) Skin tumors were predominantly benign squamous cell papillomas.

(f) Doses are presented in ug/cm²-day rather than total ug/cm².

TABLE 4-1

POTENTIAL EXPOSURE PATHWAYS FOR THE H.O.D. LANDFILL SITE

Exposure Medium	Mechanisms of Release	Exposure Point	Potential Receptor	Route of Exposure	Pathway Potentially Complete?	Quantitatively Evaluated? Basis.
Air	Volatilization from the landfill	On site	Workers, trespassers	Inhalation	Yes	No. This pathway was not evaluated since inhalation by nearby residents were evaluated and this long-term analysis would result in a higher exposure to chemicals of potential concern than would an intermittent short-term trespassing scenario.
Air	Volatilization from the landfill	Off site	Residents	Inhalation	Yes	Yes. On-site landfill gas data was used to model exposures to nearby residents.
Air	Volatilization from surface water	On site, Sequoit Creek	Workers, trespassers	Inhalation	Yes	No. Only two VOCs were detected in surface water and these were detected infrequently and at low concentrations.
Air	Volatilization from surface water	Off site, Sequoit Creek	Residents	Inhalation	Yes	No. Only two VOCs were detected in surface water and these were detected infrequently and at low concentrations.
Air	Fugitive dust from surface soils	On site	Workers, trespassers	Inhalation	No	No. Surface of landfill is well vegetated.
Air	Fugitive dust from surface soils	Off site	Residents	Inhalation	No	No. Surface of landfill is well vegetated.
Soil	Direct contact with surface soils	On site	Workers, trespassers	Incidental ingestion, dermal absorption	Yes	Yes, for trespassers only since it was assumed that their potential exposures would be greater than workers. Surface soil data was used for this analysis.
Soil	Direct contact with subsurface soils	On site	Workers, trespassers	Incidental ingestion, dermal absorption	No	No. Subsurface soils were data not available and therefore the pathway was not evaluated.
Surface Water	Landfill surface runoff/groundwater recharge to Sequoit Creek	On site, Sequoit Creek	Workers, trespassers	Incidental ingestion	No	No. Surface water in Sequoit Creek is shallow and intermittent and therefore not suitable for swimming.
Surface Water	Landfill surface runoff/groundwater recharge to Sequoit Creek	On site, Sequoit Creek	Workers, trespassers	Dermal absorption	Yes	Yes, for trespassers only since it was assumed that their potential exposures would be greater than workers. Surface water data were used for this analysis.
Sediment	Direct contact with sediments	On site, Sequoit Creek	Workers, trespassers	Incidental ingestion	Yes	Yes, for trespassers only since it was assumed that their potential exposures would be greater than workers. Sediment data were used for this analysis.
Sediment	Direct contact with sediments	On site, Sequoit Creek	Workers, trespassers	Dermal absorption	Yes	Yes, for trespassers only since it was assumed that their potential exposures would be greater than workers. Sediment data were used for this analysis.

TABLE 4-1 (CON'T)

POTENTIAL EXPOSURE PATHWAYS FOR THE H.O.D. LANDFILL SITE

Exposure Medium	Mechanisms of Release	Exposure Point	Potential Receptor	Route of Exposure	Pathway Potentially Complete?	Quantitatively Evaluated? Basis.
Fish	Landfill surface runoff/groundwater recharge to Sequoit Creek	On site, Sequoit Creek	Trespassers, residents	Ingestion	Yes	No. Fishing is not known to occur at Sequoit Creek.
Groundwater	Leaching to groundwater/groundwater transport within aquifer	On site	Workers, trespassers	Ingestion, inhalation of volatiles, dermal absorption	No	No. No currently active on-site private or commercial wells in the aquifer.
Groundwater	Leaching to groundwater/groundwater transport within aquifer	Off site, private wells municipal wells	Residents	Ingestion, inhalation of volatiles, dermal absorption	Yes	Yes. Off-site monitoring well data, private well data, and municipal well data were used to evaluate this pathway.

TABLE 4-2

EXPOSURE PARAMETERS FOR INCIDENTAL INGESTION OF AND DERMAL ABSORPTION
FROM SURFACE SOIL BY SITE TRESPASSERS
[Children and Teenagers]

Parameters	Reasonable Maximum Exposure (RME) Case
Age Period	6-16 Years of Age
Soil Ingestion Rate (mg/day) (a)	110
Fraction Ingested (unitless) (b)	0.25
Skin Surface Area Available for Contact (cm ² /event x 1 event/day) (c)	6,000
Soil-to-Skin Adherence Factor (mg/cm ²) (d)	1.0
Exposure Frequency (days/year) (e)	43
Exposure Duration (years) (f)	10
Body Weight (kg) (g)	40
Averaging Time (days) (h)	25,550 or 3,650

- (a) Value is a weighted average based on USEPA guidance (USEPA 1991a, 1989a) assuming 1 year at 200 mg/day and 9 years at 100 mg/day.
- (b) A time fraction derived by dividing the time 6 to 16 year olds are assumed to play on-site (4 hours/day) by 16 hours/day, the number of waking hours during which exposure to soil could occur (e.g., Calabrese et al. 1989).
- (c) Value derived from data presented in USEPA guidance (USEPA 1985), averaging across gender and ages 6 to 16. It is assumed that hands, arms, and legs are exposed to soil.
- (d) Value recommended by USEPA guidance (USEPA 1992b).
- (e) Assumes the frequency with which an individual will visit the site is influenced by climatic conditions, e.g., air temperature. Value assumes individuals will visit the site 1 day/week during the 300 days/year when maximum air temperatures are above freezing (NOAA 1989).
- (f) Assumes children and teenagers from ages 6 to 16 play on-site.
- (g) Weighted-average value calculated from USEPA guidance (USEPA 1989b), averaging across gender and ages 6 to 16.
- (h) The USEPA guidance (USEPA 1991a, 1989a) standard assumption for a lifetime is used in calculating exposures for potential carcinogens. For noncarcinogens, the averaging time is equal to the exposure duration.

TABLE 4-3

RELATIVE ORAL BIOAVAILABILITY FACTORS FOR
CHEMICALS OF CONCERN IN SOIL AND SEDIMENT
AT THE H.O.D. LANDFILL SITE

Chemical (a)	Relative Oral Bioavailability Factor (b)
Arsenic	0.29
Beryllium	0.028
Cadmium	0.11
Chromium (as CrVI)	0.029
Thallium	0.11

- (a) For all chemicals of concern in the soil and sediment ingestion pathways not listed in this table, a default Relative Oral Bioavailability Factor of 1 was used due to lack of information.
- (b) Based on Fraser and Lum (1983). For some inorganics, fly ash leaching results were not available from Fraser and Lum (1983). Thus, the values were based on results for inorganics most likely to behave similarly, as follows: arsenic based on phosphorus, beryllium based on aluminum, and thallium based on cadmium.

TABLE 4-4
EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR INCIDENTAL
INGESTION OF SURFACE SOIL BY SITE TRESPASSERS (a)
[Children and Teenagers]

Chemical Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/kg)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (b)	TEF for Carcinogenic PAHs (c)
Organics: -----			
Benzene	7.0 (d)	8.1E-11	0.1
Benzo(b)fluoranthene	110 (d)	1.3E-10	
Bis(2-ethylhexyl)phthalate	9,600 (d)	1.1E-07	
Carbazole	130 (d)	1.5E-09	
4,4'-DDD	3.77	4.4E-11	
1,4-Dichlorobenzene	130 (d)	1.5E-09	
Methylene chloride	705 (d)	8.2E-09	
Inorganics: -----			
Beryllium	704	2.3E-10	

Chemical Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/kg)	RME Average Daily Daily Dose (ADD) (mg/kg-day) (b)
Organics: -----		
Acenaphthene	1,000 (d)	8.1E-08
Acetone	140 (d)	1.1E-08
Anthracene	46 (d)	3.7E-09
Bis(2-ethylhexyl)phthalate	9,600 (d)	7.8E-07
Carbon disulfide	6.0 (d)	4.9E-10
Dibenzofuran	620 (d)	5.0E-08
1,4-Dichlorobenzene	130 (d)	1.1E-08
Ethylbenzene	240 (d)	1.9E-08
Fluoranthene	160 (d)	1.3E-08
Fluorene	500 (d)	4.0E-08
Methylene chloride	705 (d)	5.7E-08
2-Methylnaphthalene	390 (d)	3.2E-08
Naphthalene	630 (d)	5.1E-08
Phenanthrene	250 (d)	2.0E-08
Pyrene	110 (d)	8.9E-09
Toluene	55 (d)	4.5E-09
Xylenes (total)	280 (d)	2.3E-08
Inorganics: -----		
Beryllium	704	1.6E-09
Cadmium	1,300 (d)	1.2E-08
Chromium (total)	16,100 (d)	3.8E-08

(a) Aluminum is not presented due to lack of toxicity criteria.

(b) See text for exposure assumptions.

(c) TEF is the toxic equivalency factor used to determine carcinogenic potential of carcinogenic PAHs relative to benzo[a]pyrene (USEPA 1993a).

(d) Concentration used represents the maximum detected concentration.

TABLE 4-5

DERMAL ABSORPTION PERCENTAGES FOR CHEMICALS OF
POTENTIAL CONCERN IN SOIL AND SEDIMENT
AT THE H.O.D. LANDFILL SITE (a)

Chemical	Dermal Absorption Percent	
<u>Organics:</u>		
Acenaphthene	2%	(b)
Acetone	10%	(c)
Anthracene	2%	(b)
Benzene	10%	(c)
Bis(2-ethylhexyl)phthalate	3%	(d)
Carbon disulfide	10%	(c)
Dibenzofuran	2%	(b)
4,4'-DDD	1%	(b,e)
1,4-Dichlorobenzene	10%	(c)
Ethylbenzene	10%	(c)
Fluoranthene	2%	(b)
Fluorene	2%	(b)
Methylene chloride	10%	(c)
2-Methylnaphthalene	2%	(b)
Naphthalene	2%	(b)
Phenanthrene	2%	(b)
Pyrene	2%	(b)
Toluene	10%	(c)
Xylenes (total)	10%	(c)
<u>Inorganics:</u>		
Aluminum	0	(f)
Arsenic	0	(f)
Beryllium	0	(f)
Cadmium	0	(f)
Chromium	0	(f)
Thallium	0.1%	(g)

Footnotes on the following page.

TABLE 4-5 (Continued)

DERMAL ABSORPTION PERCENTAGES FOR CHEMICALS OF
POTENTIAL CONCERN IN SOIL AND SEDIMENT
AT THE H.O.D. LANDFILL SITE (a)

- (a) Dermal absorption percentages reflect the percentage of the chemical in contacted media which is absorbed across the skin. Factors are shown for those chemicals of concern for which oral toxicity criteria are available.
- (b) Based on Wester et al. (1990).
- (c) Value for these organic chemicals of concern is a conservative assumed value as insufficient data are available for these chemicals.
- (d) Based on Poiger and Schlatter (1980) by analogy to 2,3,7,8-TCDD.
- (e) Based on analogy to DDT.
- (f) Unlikely to undergo significant dermal absorption from sediment [Skog and Wahlberg (1964), Wahlberg (1968a,b), Lang and Kunze (1948), and Moore et al. (1980)].
- (g) Based on Klaasen et al. (1986).

TABLE 4-6
EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR DERMAL
ABSORPTION WITH SURFACE SOIL BY SITE TRESPASSERS (a)
[Children and Teenagers]

Chemicals Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/kg)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (b)
Organics: -----		
Benzene	7 (c)	4.4E-10
Bis(2-ethylhexyl)phthalate	9,600 (c)	1.8E-07
4,4'-DDD	3.77	2.4E-11
1,4-Dichlorobenzene	130 (c)	8.2E-09
Methylene chloride	705 (c)	4.4E-08
Chemicals Exhibiting Noncarcinogenic Effects	Exposure Point Concentration (ug/kg)	RME Average Daily Dose (ADD) (mg/kg-day) (b)
Organics: -----		
Acenaphthene	1,000 (c)	8.8E-08
Acetone	140 (c)	6.2E-08
Anthracene	46 (c)	4.1E-09
Bis(2-ethylhexyl)phthalate	9,600 (c)	1.3E-06
Carbon disulfide	6 (c)	2.7E-09
Dibenzofuran	620 (c)	5.5E-08
1,4-Dichlorobenzene	130 (c)	5.7E-08
Ethylbenzene	240 (c)	1.1E-07
Fluoranthene	160 (c)	1.4E-08
Fluorene	500 (c)	4.4E-08
Methylene chloride	705 (c)	3.1E-07
2-Methylnaphthalene	390 (c)	3.4E-08
Naphthalene	630 (c)	5.6E-08
Phenanthrene	250 (c)	2.2E-08
Pyrene	110 (c)	9.7E-09
Toluene	55 (c)	2.4E-08
Xylenes (total)	280 (c)	1.2E-07

(a) Aluminum is not presented due to lack of toxicity criteria. Beryllium, cadmium, and chromium are not presented due to insignificant dermal absorption. Dermal exposure to carcinogenic PAHs is evaluated separately, in Section 5.

(b) See text for exposure assumptions.

(c) Concentration represents the maximum detected concentration.

TABLE 4-7

EXPOSURE PARAMETERS FOR DERMAL CONTACT WITH
SURFACE WATER BY SITE TRESPASSERS
[Children and Teenagers]

Parameters	Reasonable Maximum Exposure (RME) Case
Age Period	6-16 Years of Age
Skin Surface Area Available for Contact (cm ²) (a)	5,300
Dermal Exposure Frequency (days/year) (b)	35
Exposure Time (hours/event) (c)	1
Exposure Events (events/day) (c)	1
Exposure Duration (years) (d)	10
Body Weight (kg) (e)	40
Averaging Time (days) (f)	25,550 or 3,650

- (a) Value derived from data presented in USEPA guidance (USEPA 1985), assumes that hands, legs, and feet are exposed during wading.
- (b) Assumes the frequency with which an individual will play in surface water is influenced by climatic conditions, e.g., air temperature. It is assumed that individuals will contact surface water 2 days/week during the four months (June-September) when average daily maximum air temperatures are above 70°F (NOAA 1989).
- (c) Value based on recommendations made by USEPA guidance (USEPA 1992b).
- (d) Assumes children and teenagers from ages 6 to 16 play in surface water.
- (e) Weighted-average value calculated from USEPA guidance (USEPA 1989b), averaging across gender and ages 6 to 16.
- (f) The USEPA guidance (USEPA 1991a, 1989a) standard assumption for a lifetime is used in calculating exposures for potential carcinogens. For noncarcinogens, the averaging time is equal to the exposure duration.

TABLE 4-8

DERMAL PERMEABILITY COEFFICIENTS FOR CHEMICALS
OF POTENTIAL CONCERN IN SURFACE WATER AND GROUNDWATER
AT THE H.O.D. LANDFILL SITE

Chemical	Dermal Permeability Coefficient (Kp) (cm/hr)
<u>Organics:</u>	
Acetone	0.0006
Carbon disulfide	0.5
4-Chloroaniline	0.006 (a)
Chloroform	0.13
1,2-Dichloroethane	0.0053
1,2-Dichloroethene	0.01
4-Methyl-2-pentanone	0.004 (a)
2-Methylphenol (o-cresol)	0.016
Vinyl chloride	0.0073
<u>Inorganics:</u>	
Antimony	0.001
Arsenic	0.001
Barium	0.001
Beryllium	0.001
Chromium	0.001
Cobalt	0.0004
Copper	0.001
Manganese	0.001
Nickel	0.0001
Zinc	0.0006

SOURCE: USEPA (1992b). Experimental value used if available, otherwise a default value of 0.001 (for inorganics) or an estimated value using the equation $\log Kp = -2.72 + 0.71 \log Kow - 0.0061 MW$ (for organics) was used.

(a) Calculated value based on USEPA (1992b).

TABLE 4-9

EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR DERMAL
CONTACT WITH SURFACE WATER BY SITE TRESPASSERS (a)
[Children and Teenagers]

Chemicals Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/L)	RME Average Daily Dose (ADD) (mg/kg-day) (b)
Organics: 4-Methyl-2-pentanone	2.0 (c)	1.7E-07
Inorganics: Antimony	17	2.2E-07
Barium	22.6 (c)	2.9E-07

(a) ADDs have been calculated for those chemicals of potential concern with toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: 2-hexanone and lead.

(b) See text for exposure assumptions.

(c) Concentration used represents the maximum detected concentration.

TABLE 4-10

EXPOSURE PARAMETERS FOR INCIDENTAL INGESTION OF AND DERMAL ABSORPTION FROM
SEDIMENT BY SITE TRESPASSERS
[Children and Teenagers]

Parameters	Reasonable Maximum Exposure (RME) Case
Age Period	6-16 Years of Age
Sediment Ingestion Rate (mg/day) (a)	110
Fraction Ingested (unitless) (b)	0.06
Skin Surface Area Available for Contact (cm ² /event x 1 event/day) (c)	1,600
Soil-to-Skin Adherence Factor (mg/cm ²) (d)	1.0
Exposure Frequency (days/year) (e)	35
Exposure Duration (years) (f)	10
Body Weight (kg) (g)	40
Averaging Time (days) (h)	25,550 or 3,650

- (a) Value is a weighted average based on USEPA (1991, 1989a) assuming 1 year at 200 mg/day and 9 years at 100 mg/day.
- (b) A time fraction derived by dividing the time 6 to 16 year olds are assumed to play in sediments (1 hour/day) by 16 hours/day, the number of waking hours during which exposure to soil or sediment could occur (e.g., Calabrese et al. 1989).
- (c) Value derived from data presented in USEPA guidance (USEPA 1985), averaging across gender and ages 6 to 16. It is assumed that hands and feet are exposed to sediment.
- (d) Value recommended by USEPA guidance (USEPA 1992b).
- (e) Assumes the frequency with which an individual will contact creek sediment is influenced by climatic conditions, e.g., air temperature. It is assumed that individuals will contact surface water 2 days/week during the four months (June-September) when average daily maximum air temperatures are above 70°F (NOAA 1989).
- (f) Assumes children and teenagers from ages 6 to 16 play on-site.
- (g) Weighted-average value calculated from USEPA guidance (USEPA 1989b), averaging across gender and ages 6 to 16.
- (h) The USEPA guidance (USEPA 1991a, 1989a) standard assumption for a lifetime is used in calculating exposures for potential carcinogens. For noncarcinogens, the averaging time is equal to the exposure duration.

TABLE 4-11
EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR INCIDENTAL
INGESTION OF SEDIMENT BY SITE TRESPASSERS
[Children and Teenagers]

Chemical Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/kg)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (a)	TEF for Carcinogenic PAHs (b)
Organics:			
Benzo(a)anthracene	250 (c)	5.7E-11	0.1
Benzo(a)pyrene	290 (c)	6.6E-10	1.0
Benzo(b)fluoranthene	430 (c)	9.7E-11	0.1
Bis(2-ethylhexyl)phthalate	1,500 (c)	3.4E-09	
Chrysene	300 (c)	6.8E-12	0.01
Inorganics:			
Arsenic	7,200 (c)	4.7E-09	
Chemical Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/kg)	RME Average Daily Daily Dose (ADD) (mg/kg-day) (a)	
Organics:			
Bis(2-ethylhexyl)phthalate	1,500 (c)	2.4E-08	
Fluoranthene	680 (c)	1.1E-08	
Phenanthrene	310 (c)	4.9E-09	
Pyrene	580 (c)	9.2E-09	
Inorganics:			
Arsenic	7,200 (c)	3.3E-08	
Thallium	3,900 (c)	6.8E-09	

(a) See text for exposure assumptions.

(b) TEF is the toxic equivalency factor used to determine carcinogenic potential of carcinogenic PAHs relative to benzo(a)pyrene (USEPA 1993a).

(c) Concentration used represents the maximum detected concentration.

TABLE 4-12

EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR DERMAL
 ABSORPTION WITH SEDIMENT BY SITE TRESPASSERS
 [Children and Teenagers]

Chemicals Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/kg)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (a)
Organics: -----		
Bis(2-ethylhexyl)phthalate	1,500 (c)	1.5E-09
Chemicals Exhibiting Noncarcinogenic Effects	Exposure Point Concentration (ug/kg)	RME Average Daily Dose (ADD) (mg/kg-day) (a)
Organics: -----		
Bis(2-ethylhexyl)phthalate	1,500 (c)	1.0E-08
Fluoranthene	680 (c)	3.1E-09
Phenanthrene	310 (c)	1.4E-09
Pyrene	580 (c)	2.7E-09
Inorganics: -----		
Thallium	3,900 (c)	9.0E-10

(a) Arsenic is not presented due to insignificant dermal absorption. Dermal exposure to carcinogenic PAHs is evaluated separately, in Section 5.

(b) Concentration represents the maximum detected concentration.

TABLE 4-13

EXPOSURE PARAMETERS FOR INGESTION OF GROUNDWATER
BY NEARBY ADULT RESIDENTS

Parameters	Reasonable Maximum Exposure (RME) Case
Water Ingestion Rate (liters/day) (a)	2
Ingestion Exposure Frequency (days/year) (b)	350
Exposure Duration (years) (c)	30
Body Weight (kg) (d)	70
Averaging Time (days) (e)	25,550 or 10,950

(a) Value is standard default assumption for residential ingestion of groundwater (USEPA 1991a, 1989a).

(b) Standard default value provided by USEPA guidance (USEPA 1991a) for ingestion of drinking water.

(c) Based on the national upper bound time at one residence (USEPA 1991a, 1989a).

(d) Standard default assumption based on USEPA guidance (USEPA 1991a, 1989a).

(e) The USEPA guidance (USEPA 1991a, 1989a) standard assumption for a lifetime is used in calculating exposures for potential carcinogens. For noncarcinogens, the averaging time is equal to the exposure duration.

TABLE 4-14

EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR INGESTION OF GROUNDWATER
FROM OFF-SITE MONITORING WELLS BY NEARBY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/l)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (b)
SURFICIAL SAND =====		
Inorganics:		
Beryllium	0.95 (c)	1.1E-05
DEEP SAND/GRAVEL =====		
Organics:		
Vinyl chloride	35 (c)	4.1E-04
Chemicals Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/l)	RME Average Daily Dose (ADD) (mg/kg-day) (b)
SURFICIAL SAND =====		
Inorganics:		
Beryllium	0.95 (c)	2.6E-05
Chromium (total)	2.95 (c)	8.1E-05
Manganese	1,090 (c)	3.0E-02
DEEP SAND/GRAVEL =====		
Organics:		
1,2-Dichloroethene (total)	18 (c)	4.9E-04
Inorganics:		
Barium	163 (c)	4.5E-03
Chromium (total)	4.3 (c)	1.2E-04
Manganese	141 (c)	3.9E-03
Nickel	5.2 (c)	1.4E-04
Zinc	314 (c)	8.6E-03

(a) LADDs and ADDs have been calculated for those chemicals of potential concern with toxicity criteria. The following chemical is not presented due to lack of toxicity criteria: cobalt (surficial sand).

(b) See text for exposure assumptions.

(c) Concentration used represents the maximum detected concentration.

TABLE 4-15

EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR INGESTION OF GROUNDWATER
FROM MUNICIPAL WELLS AND PRIVATE WELLS BY NEARBY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/l)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (b)
MUNICIPAL WELLS =====		
Organics:		
Chloroform	0.50 (c)	5.9E-06
1,2-Dichloroethane	0.76	8.9E-06
Inorganics:		
Arsenic	4.25 (c)	5.0E-05
Chemicals Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/l)	RME Average Daily Dose (ADD) (mg/kg-day) (b)
MUNICIPAL WELLS =====		
Organics:		
Acetone	11 (c)	3.0E-04
Carbon disulfide	0.58	1.6E-05
4-Chloroaniline	0.70 (c)	1.9E-05
Chloroform	0.50 (c)	1.4E-05
cis-1,2-Dichloroethene	0.60 (c)	1.6E-05
2-Methylphenol	0.50 (c)	1.4E-05
Inorganics:		
Arsenic	4.25 (c)	1.2E-04
Barium	91 (c)	2.5E-03
Chromium (total)	0.245 (c)	6.7E-06
Manganese	10 (c)	2.7E-04
Zinc	25 (c)	6.8E-04
PRIVATE WELLS =====		
Organics:		
2-Methylphenol	0.90 (c)	2.5E-05
Inorganics:		
Chromium (total)	0.89 (c)	2.4E-05
Copper	26 (c)	7.1E-04
Zinc	608 (c)	1.7E-02

(a) LADDs and ADDs have been calculated for those chemicals of potential concern with toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: aluminum (Municipal wells) and cobalt (Private wells).

(b) See text for exposure assumptions.

(c) Concentration used represents the maximum detected concentration.

TABLE 4-16

EXPOSURE PARAMETERS FOR DERMAL CONTACT WITH
GROUNDWATER AND INHALATION OF VOLATILES WHILE SHOWERING
WITH GROUNDWATER BY ADULT RESIDENTS

Parameters	Reasonable Maximum Exposure (RME) Case
Skin Surface Area Available for Contact (cm ²) (a)	20,000
Inhalation Shower Exposure Time (hours/event) (b)	0.28
Dermal Shower Exposure Time (hours/event) (b)	0.20
Shower Exposure Events (events/day) (c)	1
Showering Exposure Frequency (days/year) (d)	350
Exposure Duration (years) (e)	30
Body Weight (kg) (f)	70
Averaging Time (days) (g)	25,550 or 10,950

(a) Value based on USEPA (1992b). It is assumed that 100% of skin surface is exposed while showering.

(b) Value based on 90th percentile shower time (12 minutes) provided by USEPA guidance (USEPA 1989a). An additional 5 minutes are included to the inhalation shower time to account for time spent in the shower room after water is turned off.

(c) Values assume individual showers one time per day 350 days/year.

(d) Standard default value provided by USEPA guidance (USEPA 1991a).

(e) Based on the national upper bound time at one residence (USEPA 1991a, 1989a).

(f) Standard default assumption based on USEPA guidance (USEPA 1991a, 1989a).

(g) The USEPA guidance (USEPA 1991a, 1989a) standard assumption for a lifetime is used in calculating exposures for potential carcinogens. For noncarcinogens, the averaging time is equal to the exposure duration.

TABLE 4-17

EXPOSURE POINT CONCENTRATIONS FOR INHALATION OF VOLATILES WHILE SHOWERING WITH GROUNDWATER
FROM MONITORING AND MUNICIPAL WELLS BY NEARBY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/l)	Shower Room Air Concentration (ug/m ³)	IEC Concentration (ug/m ³) (b)
OFF SITE (Deep Sand/Gravel) =====			
Organics:			
Vinyl chloride	35.0 (c)	153	7.3E-01
MUNICIPAL WELLS =====			
Organics:			
Chloroform	0.5 (c)	1.6	7.7E-03
1,2-Dichloroethane	0.76	2.5	1.2E-02
Chemicals Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/l)	Shower Room Air Concentration (mg/m ³)	IEC Concentration (mg/m ³) (b)
MUNICIPAL WELLS =====			
Organics:			
Carbon disulfide	0.58	0.0021	2.3E-05

- (a) IECs are calculated for those chemicals of potential concern which readily volatilize and have toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: cis-1,2-Dichloroethene (Off Site and Municipal Wells) and acetone (Municipal Wells).
- (b) Inhalation Exposure Concentrations are calculated by multiplying the RME concentration by the modifying factors. These modifying factors include adjustment for shower time (0.28 hours/24 hours), exposure frequency adjustment (350 days/365 days), and exposure duration adjustment for carcinogens (30 years/70 years).
- (c) Concentration used represents the maximum detected concentration.

TABLE 4-18

EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR DERMAL CONTACT
WITH GROUNDWATER FROM OFF-SITE MONITORING WELLS BY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/L)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (b)
SURFICIAL SAND =====		
Inorganics:		
Beryllium	0.95 (c)	2.2E-08
DEEP SAND/GRAVEL =====		
Organics:		
Vinyl chloride	35 (c)	1.7E-05
Chemicals Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/L)	RME Average Daily Dose (ADD) (mg/kg-day) (b)
SURFICIAL SAND =====		
Inorganics:		
Beryllium	0.95 (c)	5.2E-08
Chromium (total)	2.95 (c)	1.6E-07
Manganese	1,090 (c)	6.0E-05
DEEP SAND AND GRAVEL =====		
Organics:		
1,2-Dichloroethene (total)	18 (c)	3.6E-05
Inorganics:		
Barium	163 (c)	8.9E-06
Chromium (total)	4.3 (c)	2.4E-07
Manganese	141 (c)	7.7E-06
Nickel	5.2 (c)	2.8E-08
Zinc	314 (c)	1.0E-05

(a) LADDs and ADDs have been calculated for those chemicals of potential concern with toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: aluminum (Municipal Wells) and cobalt (Private wells).

(b) See text for exposure assumptions.

(c) Concentration used represents the maximum detected concentration.

TABLE 4-19

EXPOSURE POINT CONCENTRATIONS AND AVERAGE DAILY DOSES FOR DERMAL CONTACT
WITH GROUNDWATER FROM MUNICIPAL WELLS AND PRIVATE WELLS BY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Exposure Point Concentration (ug/L)	RME Lifetime Average Daily Dose (LADD) (mg/kg-day) (b)
MUNICIPAL WELLS =====		
Organics:		
Chloroform	0.50 (c)	6.5E-06
1,2-Dichloroethane	0.76	3.5E-07
Inorganics:		
Arsenic	4.25 (c)	1.0E-07
Chemicals Exhibiting Noncarcinogenic Effects	RME Exposure Point Concentration (ug/L)	RME Average Daily Dose (ADD) (mg/kg-day) (b)
MUNICIPAL WELLS =====		
Organics:		
Acetone	11 (c)	9.9E-07
Carbon disulfide	0.58	5.1E-05
4-Chloroaniline	0.70 (c)	1.0E-06
Chloroform	0.50 (c)	1.5E-05
cis-1,2-Dichloroethene	0.60 (c)	1.2E-06
2-Methylphenol	0.50 (c)	1.7E-06
Inorganics:		
Arsenic	4.25 (c)	2.3E-07
Barium	91 (c)	5.0E-06
Chromium (total)	0.245 (c)	1.3E-08
Manganese	10 (c)	5.5E-07
Zinc	25 (c)	8.2E-07
PRIVATE WELLS =====		
Organics:		
2-Methylphenol	0.90 (c)	3.1E-06
Inorganics:		
Chromium (total)	0.89 (c)	4.9E-08
Copper	26 (c)	1.4E-06
Zinc	608 (c)	2.0E-05

(a) LADDs and ADDs have been calculated for those chemicals of potential concern with toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: aluminum (Municipal Wells) and cobalt (Private wells).

(b) See text for exposure assumptions.

(c) Concentration used represents the maximum detected concentration.

TABLE 4-20

EXPOSURE PARAMETERS FOR INHALATION OF
VOLATILE ORGANIC CHEMICALS EMITTED INTO AMBIENT AIR
BY ADULT RESIDENTS

Parameters	Reasonable Maximum Exposure (RME) Case
Exposure Frequency (days/year) (a)	350
Exposure Duration (years) (b)	30
Exposure Time (hours/day) (c)	24
Body Weight (kg) (d)	70
Averaging Time (days) (e)	25,550 or 10,950

- (a) Standard default value provided by USEPA (1991a).
 (b) Based on upper-bound time at one residence (USEPA 1991a, 1989a).
 (c) Assumes residents are exposed to landfill emissions 24 hours a day.
 (d) Standard default assumption based on USEPA guidance (USEPA 1991a, 1989a).
 (e) The USEPA guidance (USEPA 1991a, 1989a) standard assumption for a lifetime is used in calculating exposures for potential carcinogens. For noncarcinogens, the averaging time is equal to the exposure duration.

TABLE 4-21

EXPOSURE POINT CONCENTRATIONS FOR INHALATION BY ADULT RESIDENTS
OF VOLATILES EMITTED INTO AMBIENT AIR (a)

Chemicals Exhibiting Carcinogenic Effects	Landfill Gas Exposure Concentration (ppb) (b)	Air Concentration (ug/m ³)	IEC Concentration (ug/m ³) (c)
Organics:			
Benzene	550	1.10E-03	4.5E-04
Chloromethane	290	4.67E-04	1.9E-04
1,1-Dichloroethene	170	3.79E-04	1.6E-04
Methylene chloride	320	6.67E-04	2.7E-04
Tetrachloroethene	1,700	5.73E-03	2.4E-03
Trichloroethene	850	2.20E-03	9.0E-04
Vinyl chloride	8,000	1.43E-02	5.9E-03
Chemicals Exhibiting Noncarcinogenic Effects	Landfill Gas Exposure Concentration (ppb) (b)	Air Concentration (mg/m ³)	IEC Concentration (mg/m ³) (c)
Organics:			
2-Butanone	5,900	1.04E-05	1.0E-05
Carbon disulfide	400	7.89E-07	7.6E-07
Chlorobenzene	1,000	2.22E-06	2.1E-06
Chloroethane	450	8.20E-07	7.9E-07
1,1-Dichloroethane	220	4.95E-07	4.7E-07
Ethylbenzene	5,600	1.19E-05	1.1E-05
Methylene chloride	320	6.67E-07	6.4E-07
Toluene	30,000	5.95E-05	5.7E-05

(a) Inhalation Exposure Concentrations (IECs) are calculated for those chemicals of potential concern which readily volatilize and have toxicity criteria. The following chemicals are not presented due to lack of inhalation toxicity criteria: acetone, cis-1,2-dichloroethene, 4-ethyltoluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene and xylenes.

(b) Arithmetic mean landfill gas concentrations are used to model ambient air concentrations (see text).

(c) IECs are calculated by multiplying the air concentration by modifying factors. These modifying factors include exposure frequency adjustment (350 days/365 days) for all chemicals and exposure duration adjustment only for carcinogens (30 years/70 years).

TABLE 4-22

COMPARISON OF DRINKING WATER STANDARDS TO ON-SITE GROUNDWATER CONCENTRATIONS
FOR CHEMICALS OF CONCERN
H.O.D. LANDFILL

Chemical	Drinking Water Standards and Goals			Deep Sand and Gravel Groundwater			Surficial Sand Groundwater		
	Federal MCL (mg/L)	Federal MCLG (mg/L)	State of Illinois Groundwater Quality Standard (mg/L)	Arithmetic Mean Concentration (mg/L)	Maximum Concentration (mg/L)	Frequency of Detection	Arithmetic Mean Concentration (mg/L)	Maximum Concentration (mg/L)	Frequency of Detection
Carbon disulfide	No Data	No Data	No Data	NA	NA	NA	0.0057	0.018	2/12
Chromium	0.1	0.1	0.1	0.0022	0.0035	1/3	0.0021 (c)	0.004	1/5
1,2-Dichloroethene	No Data	No Data	0.07 (a) 0.1 (b)	NA	NA	NA	0.011	0.044	3/12
Manganese	No Data	0.05	0.15	0.027	0.032	3/3	0.32	0.75	5/5
Thallium	0.002	0.0004	0.002	0.0014	0.0021	1/3	NA	NA	NA
Trichloroethene	0.005	0	0.005	NA	NA	NA	0.0015	0.002	2/12
Vinyl Chloride	0.002	No Data	0.002	NA	NA	NA	0.0062 (c)	0.019	1/12

a) Value for cis-isomer.

b) Value for trans-isomer.

c) Mean concentrations are highly uncertain when based on a low frequency of detection.

NA = Not applicable since this compound was not a selected chemical of concern.

TABLE 5--1
ABSOLUTE ORAL ABSORPTION FACTORS

Chemical	Oral Absorption Fraction (a)	Basis of Oral Absorption Fraction (b)	References (c)
Organics:			
Acenaphthene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
Acetone	0.83	Rats; gavage	ATSDR -- October 1992
Anthracene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
Benzene	1	Rats and mice	ATSDR -- October 1991
Benzo(a)anthracene	1	Default; insufficient data available	
Benzo(a)pyrene	1	Default; insufficient data available	
Benzo(b)fluoranthene	1	Default; insufficient data available	
Bis(2-ethylhexyl) phthalate	0.55	Rats	ATSDR -- October 1991
Carbazole	1	Default; insufficient data available	
Carbon disulfide	1	Default; insufficient data available	
4-Chloroaniline	1	Default; insufficient data available	
Chloroform	0.98	Mice, rats and monkeys; gavage	ATSDR -- October 1991
Chrysene	1	Default; insufficient data available	
4,4'-DDD	0.9	Based on analogy to DDT	ATSDR -- October 1992
Dibenzofuran	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
1,4-Dichlorobenzene	1	Default; insufficient data available	
1,2-Dichloroethane	1	Default; insufficient data available	
1,2-Dichloroethene	1	Default; insufficient data available	
Ethylbenzene	0.92	Rabbits	ATSDR -- December 1990
Fluoranthene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
Fluorene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
Methylene chloride	0.98	Mice; aqueous solution	ATSDR -- October 1991
2-Methylnaphthalene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
4-Methyl-2-pentanone	1	Default; insufficient data available	
2-Methylphenol	1	Default; insufficient data available	
Naphthalene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
Phenanthrene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
Pyrene	0.84	Rats; corn oil	ATSDR -- December 1990 (d)
Toluene	0.99	Rabbits	ECAO -- Pei Fung Hurst 8/91
Vinyl chloride	1	Default; insufficient data available	
Xylenes	0.92	Animal (not specified)	ATSDR -- December 1990
Inorganics:			
Antimony	0.1	Antimony tartrate	ATSDR -- February 1992
Arsenic	1.0	Humans; drinking water	IRIS
Barium	0.05	Humans	ATSDR -- October 1990
Beryllium	0.005	Rats; drinking water (beryllium sulfate)	ATSDR -- October 1991
Cadmium	0.07	Humans	ATSDR -- October 1991
Chromium	0.1	Humans	ATSDR -- October 1991 (e)
Copper	0.97	Humans; copper acetate	ATSDR -- September 1990
Manganese	0.055	Rats	ATSDR -- October 1990
Nickel	0.1	Rats and dogs; diet and gavage	ATSDR -- October 1991
Thallium	1	Default; insufficient data available	ATSDR -- April 1991
Zinc	0.3	Humans	ATSDR -- December 1989

- (a) Portion of chemical actually absorbed following oral exposure. This value is used to convert the oral RfDs and cancer slope factors (CSFs) to absorbed doses. These factors were selected from studies which most resembled conditions employed in the primary studies used to derive the oral RfDs and CSFs.
- (b) Factors shown under basis were identified as follows, only if available: species tested; route of administration; vehicle used and/or chemical form.
- (c) ATSDR = Agency for Toxic Substances and Disease Registry. Toxicity profiles for chemical listed, unless otherwise noted. U.S. Department of Health and Human Services. Public Health Service.
 IRIS = USEPA Integrated Risk Information System, EPA assumed 100% absorption of arsenic in deriving the RfD.
 ECAO = Environmental Criteria and Assessment Office.
- (d) Based on the average oral absorption for two noncarcinogenic PAHs (phenanthracene and anthracene).
- (e) The absorption factor for chromium VI was used in order to be consistent with the toxicity criteria used to calculate risk.

TABLE 5-2
POTENTIAL RISKS ASSOCIATED WITH INCIDENTAL INGESTION
OF SURFACE SOIL BY SITE TRESPASSERS (a)
[Children and Teenagers]

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence Class (b)	RME Upper Bound Excess Lifetime Cancer Risk
Organics:				
Benzene	8.1E-11 (e)	2.9E-02	A	2E-12
Benzo(b)fluoranthene	1.3E-10 (e)	7.3E+00	B2	9E-10
Bis(2-ethylhexyl)phthalate	1.1E-07 (e)	1.4E-02	B2	2E-09
Carbazole	1.5E-09 (e)	2E-02	B2	3E-11
4,4'-DDD	4.4E-11	2.4E-01	B2	1E-11
1,4-Dichlorobenzene	1.5E-09 (e)	2.4E-02	B2	4E-11
1,2-Dichloroethane	8.2E-09 (e)	7.5E-03	B2	6E-11
Inorganics:				
Beryllium	2.3E-10	4.3E+00	B2	1E-09
TOTAL				4E-09

Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) [Uncertainty Factor] (c)	Target Organ/ Critical Effect (d)	RME ADD:RfD Ratio
Organics				
Acenaphthene	8.1E-08 (e)	6E-02 [3,000]	Liver	1.3E-06
Acetone	1.1E-08 (e)	1E-01 [1,000]	Kidney/Liver	1.1E-07
Anthracene	3.7E-09 (e)	3E-01 [3,000]	None Observed	1.2E-08
Bis(2-ethylhexyl)phthalate	7.8E-07 (e)	2E-02 [1,000]	Liver	3.9E-05
Carbon disulfide	4.9E-10 (e)	1E-01 [100]	Fetotoxicity	4.9E-09
Dibenzofuran	5.0E-08 (e)	3E-02 [3,000]	Kidney	1.7E-06
1,4-Dichlorobenzene	1.1E-08 (e)	1E-01 [1,000]	Kidney	1.1E-07
Ethylbenzene	1.9E-08 (e)	1E-01 [1,000]	Liver/Kidney	1.9E-07
Fluoranthene	1.3E-08 (e)	4E-02 [3,000]	Kidney/Liver	3.2E-07
Fluorene	4.0E-08 (e)	4E-02 [3,000]	Hematology	1.0E-06
Methylene chloride	5.7E-08 (e)	6E-02 [100]	Liver	9.5E-07
2-Methylnaphthalene	3.2E-08 (e)	3E-02 [3,000]	Kidney	1.1E-06
Naphthalene	5.1E-08 (e)	3E-02 [3,000]	Kidney	1.7E-06
Phenanthrene	2.0E-08 (e)	3E-02 [3,000]	Kidney	6.7E-07
Pyrene	8.9E-09 (e)	3E-02 [3,000]	Kidney	3.0E-07
Toluene	4.5E-09 (e)	2E-01 [1,000]	Liver/Kidney	2.2E-08
Xylenes (total)	2.3E-08 (e)	2E+00 [100]	CNS	1.1E-08
Inorganics:				
Beryllium	1.6E-09	5E-03 [100]	None Observed	3.2E-07
Cadmium	1.2E-08 (e)	1E-03 [10]	Kidney	1.2E-05
Chromium (total)	3.8E-08 (e)	5E-03 [500]	CNS	7.6E-06
HAZARD INDEX				< 1 (7E-05)

(a) Aluminum is not presented due to lack of toxicity criteria.

(b) USEPA Weight of Evidence for Carcinogenic Effects:

[A] = Human carcinogen based on adequate evidence from human studies;

[B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

(c) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.

(d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by a particular chemical of concern. The most sensitive critical effect of concern is cited in the absence of a target organ.

(e) Concentration used represents the maximum detected concentration.

TABLE 5-3

POTENTIAL RISKS ASSOCIATED WITH DERMAL ABSORPTION
FROM SURFACE SOIL BY SITE TRESPASSERS (a)
[Children and Teenagers]

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence Class (b)	Absolute Oral Absorption Factor (c)	Adjusted Slope Factor (mg/kg-day) ⁻¹ (d)	RME Upper Bound Excess Lifetime Cancer Risk
Organics -----						
Benzene	4.4E-10 (h)	2.9E-02	A	1	2.9E-02	1E-11
Bis(2-ethylhexyl)phthalate	1.8E-07 (h)	1.4E-02	B2	0.55	2.5E-02	5E-09
4,4'-DDD	2.4E-11	2.4E-01	B2	0.9	2.7E-01	6E-12
1,4-Dichlorobenzene	8.2E-09 (h)	2.4E-02	B2	1	2.4E-02	2E-10
Methylene chloride	4.4E-08 (h)	7.5E-03	B2	0.98	7.7E-03	3E-10
TOTAL						5E-09
Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) [Uncertainty Factor] (e)	Target Organ/ Critical Effect (f)	Absolute Oral Absorption Factor (c)	Adjusted Reference Dose (mg/kg-day) (g)	RME ADD:RfD Ratio
Organics -----						
Acenaphthene	8.8E-08 (h)	6E-02 [3,000]	Liver	0.84	5E-02	1.8E-06
Acetone	6.2E-08 (h)	1E-01 [1,000]	Kidney/Liver	0.83	8E-02	7.5E-07
Anthracene	4.1E-09 (h)	3E-01 [3,000]	None Observed	0.84	3E-01	1.6E-08
Bis(2-ethylhexyl)phthalate	1.3E-06 (h)	2E-02 [1,000]	Liver	0.55	1E-02	1.2E-04
Carbon disulfide	2.7E-09 (h)	1E-01 [100]	Fetotoxicity	1	1E-01	2.7E-08
Dibenzofuran	5.5E-08 (h)	3E-02 [3,000]	Kidney	0.84	3E-02	2.2E-06
1,4-Dichlorobenzene	5.7E-08 (h)	1E-01 [1,000]	Kidney	1	1E-01	5.7E-07
Ethylbenzene	1.1E-07 (h)	1E-01 [1,000]	Liver/Kidney	0.92	9E-02	1.2E-06
Fluoranthene	1.4E-08 (h)	4E-02 [3,000]	Kidney/Liver	0.84	3E-02	4.2E-07
Fluorene	4.4E-08 (h)	4E-02 [3,000]	Hematology	0.84	3E-02	1.3E-06
Methylene chloride	3.1E-07 (h)	6E-02 [100]	Liver	0.98	6E-02	5.3E-06
2-Methylnaphthalene	3.4E-08 (h)	3E-02 [3,000]	Kidney	0.84	3E-02	1.4E-06
Naphthalene	5.6E-08 (h)	3E-02 [3,000]	Kidney	0.84	3E-02	2.2E-06
Phenanthrene	2.2E-08 (h)	3E-02 [3,000]	Kidney	0.84	3E-02	8.8E-07
Pyrene	9.7E-09 (h)	3E-02 [3,000]	Kidney	0.84	3E-02	3.9E-07
Toluene	2.4E-08 (h)	2E-01 [1,000]	Liver/Kidney	0.99	2E-01	1.2E-07
Xylenes (total)	1.2E-07 (h)	2E+00 [100]	CNS	0.92	2E+00	6.7E-08
HAZARD INDEX						< 1 (1E-04)

TABLE 5-3 (con't)

POTENTIAL RISKS ASSOCIATED WITH DERMAL ABSORPTION
FROM SURFACE SOIL BY SITE TRESPASSERS (a)
[Children and Teenagers]

- (a) Aluminum, beryllium, cadmium, and chromium are not presented due to insignificant dermal absorption. Aluminum is also not presented due to lack of toxicity criteria. Dermal exposure to carcinogenic PAHs is evaluated separately, in Section 5.
- (b) USEPA Weight of Evidence for Carcinogenic Effects:
 - [A] = Human carcinogen based on adequate evidence from human studies;
 - [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Absolute oral absorption factors were obtained from the ATSDR toxicological profiles and U.S. EPA's IRIS and ECAO.
- (d) Adjusted slope factor = slope factor/absolute oral absorption factor.
- (e) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.
- (f) A target organ/critical effect is the most sensitive organ/effect to a chemical's toxic effect. RfDs are based on toxic effect in the target organ or on an effect elicited by the chemical. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by the particular chemical of concern. The most sensitive critical effect of concern is cited in the absence of a target organ.
- (g) Adjusted reference dose = (reference dose) * (absolute oral absorption factor).
- (h) Concentration represents the maximum detected concentration.

TABLE S-4
POTENTIAL RISKS ASSOCIATED WITH DERMAL CONTACT WITH
SURFACE WATER BY SITE TRESPASSERS (a)
[Children and Teenagers]

Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (RfD) (mg/kg/day) [Uncertainty Factor] (b)	Target Organ or Critical Effect (c)	Absolute Oral Absorption Fraction (d)	Adjusted Reference Dose (mg/kg/day) (e)	RME ADD:RfD Ratio
Organics:						
4-Methyl-2-pentanone	1.7E-07 (f)	8E-02 [3,000]	Liver/Kidney	1	8E-02	2.2E-06
Inorganics:						
Antimony	2.2E-07	4E-04 [1,000]	Blood Chemistry	0.1	4E-05	5.4E-03
Barium	2.9E-07 (f)	7E-02 [3]	Inc. Blood Pressure	0.05	4E-03	8.2E-05
HAZARD INDEX						< 1 (5E-03)

(a) Risks have been calculated for those chemicals of potential concern with oral toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: 2-hexanone and lead.

(b) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.

(c) A target organ or critical effect is the organ/effect most sensitive to the chemical exposure. RfDs are based on toxic effects in the target organ or critical effects. If an RfD is based on a study in which a target organ or critical effect was not identified, the organ/effect listed is one known to be influenced by the chemical.

(d) Absolute oral absorption fractions were obtained from the ATSDR toxicological profiles and USEPA's IRIS and ECAO.

(e) Adjusted Reference Dose = Reference Dose * Oral Absorption Fraction.

(f) Concentration used represents the maximum detected concentration.

TABLE 5-5
POTENTIAL RISKS ASSOCIATED WITH INCIDENTAL INGESTION
OF SEDIMENT BY SITE TRESPASSERS
[Children and Teenagers]

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence Class (a)	RME Upper Bound Excess Lifetime Cancer Risk
Organics:				
Benzo(a)anthracene	5.7E-11 (d)	7.3E+00	B2	4E-10
Benzo(a)pyrene	6.6E-10 (d)	7.3E+00	B2	5E-09
Benzo(b)fluoranthene	9.7E-11 (d)	7.3E+00	B2	7E-10
Bis(2-ethylhexyl)phthalate	3.4E-09 (d)	1.4E-02	B2	5E-11
Chrysene	6.8E-12 (d)	7.3E+00	B2	5E-11
Inorganics:				
Arsenic	4.7E-09 (d)	1.75E+00	A	8E-09
TOTAL				1E-08
Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) [Uncertainty Factor] (b)	Target Organ/ Critical Effect (c)	RME ADD:RfD Ratio
Organics				
Bis(2-ethylhexyl)phthalate	2.4E-08 (d)	2E-02 [1,000]	Liver	1.2E-06
Fluoranthene	1.1E-08 (d)	4E-02 [3,000]	Kidney/Liver	2.7E-07
Phenanthrene	4.9E-09 (d)	3E-02 [3,000]	Kidney	1.6E-07
Pyrene	9.2E-09 (d)	3E-02 [3,000]	Kidney	3.1E-07
Inorganics:				
Arsenic	3.3E-08 (d)	3E-04 [3]	Skin	1.1E-04
Thallium	6.8E-09 (d)	8E-05 [3,000]	Liver	8.5E-05
HAZARD INDEX				< 1 (2E-04)

(a) USEPA Weight of Evidence for Carcinogenic Effects:

[A] = Human carcinogen based on adequate evidence from human studies;

[B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

(b) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.

(c) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by a particular chemical of concern. The most sensitive critical effect of concern is cited in the absence of a target organ.

(d) Concentration used represents the maximum detected concentration.

TABLE 5-6
POTENTIAL RISKS ASSOCIATED WITH DERMAL ABSORPTION
FROM SEDIMENT BY SITE TRESPASSERS
[Children and Teenagers]

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence Class (a)	Absolute Oral Absorption Factor (b)	Adjusted Slope Factor (mg/kg-day) ⁻¹ (c)	RME Upper Bound Excess Lifetime Cancer Risk
Organics -----						
Bis(2-ethylhexyl)phthalate	1.5E-09 (g)	1.4E-02	B2	0.55	2.5E-02	4E-11 ----- 4E-11
TOTAL						
Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) [Uncertainty Factor] (d)	Target Organ/ Critical Effect (e)	Absolute Oral Absorption Factor (b)	Adjusted Reference Dose (mg/kg-day) (f)	RME ADD:RfD Ratio
Organics -----						
Bis(2-ethylhexyl)phthalate	1.0E-08 (g)	2E-02 [1,000]	Liver	0.55	1E-02	9.4E-07
Fluoranthene	3.1E-09 (g)	4E-02 [3,000]	Kidney/Liver	0.84	3E-02	9.3E-08
Phenanthrene	1.4E-09 (g)	3E-02 [3,000]	Kidney	0.84	3E-02	5.7E-08
Pyrene	2.7E-09 (g)	3E-02 [3,000]	Kidney	0.84	3E-02	1.1E-07
Inorganics: -----						
Thallium	9.0E-10 (g)	8E-05 [3,000]	Liver	1	8E-05	1.1E-05 ----- < 1 (1E-05)
HAZARD INDEX						

(a) USEPA Weight of Evidence for Carcinogenic Effects:

[A] = Human carcinogen based on adequate evidence from human studies;

[B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

(b) Absolute oral absorption factors were obtained from the ATSDR toxicological profiles and U.S. EPA's IRIS and ECAO.

(c) Adjusted slope factor = slope factor/absolute oral absorption factor.

(d) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.

(e) A target organ/critical effect is the most sensitive organ/effect to a chemical's toxic effect. RfDs are based on toxic effect in the target organ or on an effect elicited by the chemical. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by the particular chemical of concern. The most sensitive critical effect of concern is cited in the absence of a target organ.

(f) Adjusted reference dose = (reference dose) * (absolute oral absorption factor).

(g) Concentration represents the maximum detected concentration.

TABLE 5-7

POTENTIAL RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER FROM
OFF-SITE MONITORING WELLS BY NEARBY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence Class (b)	RME Upper Bound Excess Lifetime Cancer Risk
SURFICIAL SAND =====				
Inorganics:				
Beryllium	1.1E-05 (e)	4.3E+00	B2	5E-05 -----
TOTAL				5E-05
DEEP SAND/GRAVEL =====				
Organics:				
Vinyl chloride	4.1E-04 (e)	1.9E+00	A	8E-04 -----
TOTAL				8E-04
Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (mg/kg-day) [Uncertainty Factor] (c)	Target Organ or Critical Effect (d)	RME ADD:RfD Ratio
SURFICIAL SAND =====				
Inorganics:				
Beryllium	2.6E-05 (e)	5E-03 [100]	None Observed	5.2E-03
Chromium (total)	8.1E-05 (e)	5E-03 [500]	CNS	1.6E-02
Manganese	3.0E-02 (e)	5E-03 [1]	CNS	6.0E+00 -----
HAZARD INDEX				> 1 (6E+00)
DEEP SAND/GRAVEL =====				
Organics:				
1,2-Dichloroethene (total)	4.9E-04 (e)	9E-03 [1,000]	Liver	5.5E-02
Inorganics:				
Barium	4.5E-03 (e)	7E-02 [3]	Inc. Blood Pressure	6.4E-02
Chromium (total)	1.2E-04 (e)	5E-03 [500]	CNS	2.4E-02
Manganese	3.9E-03 (e)	5E-03 [1]	CNS	7.7E-01
Nickel	1.4E-04 (e)	2E-02 [300]	< Body Weight	7.1E-03
Zinc	8.6E-03 (e)	3E-01 [3]	Blood Chemistry	2.9E-02 -----
HAZARD INDEX				< 1 (9E-01)

(a) Risks are calculated for those chemicals of potential concern with toxicity criteria. The following chemical is not presented due to lack of toxicity criteria: cobalt (surficial sand).

(b) USEPA Weight of Evidence for Carcinogenic Effects:

[A] = Human carcinogen based on adequate evidence from human studies.

[B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

(c) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.

(d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by the particular chemical of concern.

(e) Concentrations used represent the maximum detected concentration.

TABLE 5-8

POTENTIAL RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER FROM
MUNICIPAL AND PRIVATE WELLS BY NEARBY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence Class (b)	RME Upper Bound Excess Lifetime Cancer Risk
MUNICIPAL WELLS =====				
Organics:				
Chloroform	5.9E-06 (e)	6.1E-03	B2	4E-08
1,2-Dichloroethane	8.9E-06	9.1E-02	B2	8E-07
Inorganics:				
Arsenic	5.0E-05 (e)	1.75E+00	A	9E-05
TOTAL				----- 9E-05
Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (mg/kg-day) [Uncertainty Factor] (c)	Target Organ or Critical Effect (d)	RME ADD:Rfd Ratio
MUNICIPAL WELLS =====				
Organics:				
Acetone	3.0E-04 (e)	1E-01 [1,000]	Kidney/Liver	3.0E-03
Carbon disulfide	1.6E-05	1E-01 [100]	Fetotoxicity	1.6E-04
4-Chloroaniline	1.9E-05 (e)	4E-03 [3,000]	Spleen	4.8E-03
Chloroform	1.4E-05 (e)	1E-02 [1,000]	Liver	1.4E-03
cis-1,2-Dichloroethene	1.6E-05 (e)	1E-02 [3,000]	Hematology	1.6E-03
2-Methylphenol	1.4E-05 (e)	5E-02 [1,000]	Neurotoxicity	2.7E-04
Inorganics:				
Arsenic	1.2E-04 (e)	3E-04 [3]	Skin	3.9E-01
Barium	2.5E-03 (e)	7E-02 [3]	Inc. Blood Pressure	3.6E-02
Chromium (total)	6.7E-06 (e)	5E-03 [500]	CNS	1.3E-03
Manganese	2.7E-04 (e)	5E-03 [1]	CNS	5.5E-02
Zinc	6.8E-04 (e)	3E-01 [3]	Blood Chemistry	2.3E-03
HAZARD INDEX				----- < 1 (5E-01)
PRIVATE WELLS =====				
Organics:				
2-Methylphenol	2.5E-05 (e)	5E-02 [1,000]	Neurotoxicity	4.9E-04
Inorganics:				
Chromium (total)	2.4E-05 (e)	5E-03 [500]	CNS	4.9E-03
Copper	7.1E-04 (e)	3.7E-02 [1]	GI Irritation	1.9E-02
Zinc	1.7E-02 (e)	3E-01 [3]	Blood Chemistry	5.6E-02
HAZARD INDEX				----- < 1 (8E-02)

(a) Risks are calculated for those chemicals of potential concern with toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: aluminum (Municipal wells) and cobalt (Private wells).

(b) USEPA Weight of Evidence for Carcinogenic Effects:

[A] = Human carcinogen based on adequate evidence from human studies.

[B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

(c) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.

(d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by the particular chemical of concern.

(e) Concentrations used represent the maximum detected concentration.

TABLE 5-9

POTENTIAL RISKS ASSOCIATED WITH INHALATION OF VOLATILES WHILE SHOWERING WITH GROUNDWATER
FROM MONITORING AND MUNICIPAL WELLS BY NEARBY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogen - Effects	IEC Concentration (ug/m ³) (b)	Unit Risk (ug/m ³) ⁻¹	Weight of Evidence Class (c)	RME Upper Bound Excess Lifetime Cancer Risk
OFF SITE (Deep Sand/Gravel) =====				
Organics:				
Vinyl chloride	7.3E-01 (e)	8.4E-05	A	6.2E-05 ----- 6E-05
TOTAL				
MUNICIPAL WELLS =====				
Organics:				
Chloroform	7.7E-03 (e)	2.3E-05	B2	1.8E-07
1,2-Dichloroethane	1.2E-02	2.6E-05	B2	3.1E-07 ----- 5E-07
TOTAL				
Chemicals Exhibiting Noncarcinogenic Effects	IEC Concentration (mg/m ³) (b)	Reference Concentration (RfC) (mg/m ³) [Uncertainty Factor] (d)	Target Organ or Critical Effect (f)	RME ADD:RfD Ratio
MUNICIPAL WELLS =====				
Organics:				
Carbon disulfide	2.3E-05	1E-02 [1,000]	Fetotoxicity	2.3E-03 ----- < 1 (2E-03)
HAZARD INDEX				

- (a) Risks are calculated for those chemicals of potential concern which readily volatilize and have toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: 1,2-dichloroethene (Off Site and Municipal Wells) and acetone (Municipal Wells).
- (b) Inhalation Exposure Concentrations (IECs) are calculated by multiplying the RME concentration by the modifying factors. These modifying factors applied to the risk calculation include adjustment for shower time (0.28 hours/24 hours), exposure frequency adjustment (350 days/365 days), and exposure duration adjustment for carcinogens (30 years/70 years).
- (c) USEPA Weight of Evidence for Carcinogenic Effects:
 [A] Human carcinogen based on adequate evidence from human studies.
 [B2] Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (d) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.
- (e) Concentrations used represent the maximum detected concentration.
- (f) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by the particular chemical of concern.

TABLE 5-10

POTENTIAL RISKS ASSOCIATED WITH DERMAL CONTACT WITH GROUNDWATER FROM
OFF-SITE MONITORING WELLS BY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence Class (b)	Absolute Oral Absorption Fraction (c)	Adjusted Slope Factor (mg/kg/day) ⁻¹ (d)	RME Upper Bound Excess Lifetime Cancer Risk
SURFICIAL SAND =====						
Inorganics:						
Beryllium	2.2E-08 (h)	4.3E+00	B2	0.005	9E+02	2E-05 ----- 2E-05
DEEP SAND/GRAVEL =====						
Organics:						
Vinyl chloride	1.7E-05 (h)	1.9E+00	A	1	1.9	3E-05 ----- 3E-05
TOTAL						
Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (mg/kg-day) [Uncertainty Factor] (e)	Target Organ or Critical Effect (f)	Absolute Oral Absorption Fraction (c)	Adjusted Reference Dose (mg/kg/day) (g)	RME ADD:RfD Ratio
SURFICIAL SAND =====						
Inorganics:						
Barium	5.2E-08 (h)	7E-02 [3]	Inc. Blood Pressure	0.05	4E-03	1.5E-05
Chromium (total)	1.6E-07 (h)	5E-03 [500]	CNS	0.1	5E-04	3.2E-04
Manganese	6.0E-05 (h)	5E-03 [1]	CNS	0.055	3E-04	2.2E-01 ----- < 1 (2E-01)
HAZARD INDEX						
DEEP SAND AND GRAVEL =====						
Organics:						
1,2-Dichloroethene (total)	3.6E-05 (h)	9E-03 [1,000]	Liver	1	9E-03	4.0E-03
Inorganics:						
Barium	8.9E-06 (h)	7E-02 [3]	Inc. Blood Pressure	0.05	4E-03	2.6E-03
Chromium (total)	2.4E-07 (h)	5E-03 [500]	CNS	0.1	5E-04	4.7E-04
Manganese	7.7E-06 (h)	5E-03 [1]	CNS	0.055	3E-04	2.8E-02
Nickel	2.8E-08 (h)	2E-02 [300]	< Body Weight	0.1	2E-03	1.4E-05
Zinc	1.0E-05 (h)	3E-01 [3]	Blood Chemistry	0.3	9E-02	1.1E-04 ----- < 1 (4E-02)
HAZARD INDEX						

- (a) Risks have been calculated for those chemicals of potential concern with oral toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: cobalt (surficial sand).
- (b) USEPA Weight of Evidence for Carcinogenic Effects:
 [A] = Human carcinogen based on adequate evidence from human studies.
 [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Absolute oral absorption fractions were obtained from the ATSDR toxicological profiles and U.S. EPA's IRIS and ECAO.
- (d) Adjusted Slope Factor = Slope Factor / Oral Absorption Fraction.
- (e) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.
- (f) A target organ or critical effect is the organ/effect most sensitive to the chemical exposure. RfDs are based on toxic effects in the target organ or critical effects. If an RfD is based on a study in which a target organ or critical effect was not identified, the organ/effect listed is one known to be influenced by the chemical.
- (g) Adjusted Reference Dose = Reference Dose * Oral Absorption Fraction.
- (h) Concentration used represents the maximum detected concentration.

TABLE 5-11

POTENTIAL RISKS ASSOCIATED WITH DERMAL CONTACT WITH GROUNDWATER
FROM MUNICIPAL WELLS AND PRIVATE WELLS BY ADULT RESIDENTS (a)

Chemicals Exhibiting Carcinogenic Effects	RME Lifetime Average Daily Dose (LADD) (mg/kg-day)	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence Class (b)	Absolute Oral Absorption Fraction (c)	Adjusted Slope Factor (mg/kg/day) ⁻¹ (d)	RME Upper Bound Excess Lifetime Cancer Risk
MUNICIPAL WELLS =====						
Organics:						
Chloroform	6.5E-06 (h)	6.1E-03	B2	0.98	6E-03	4E-08
1,2-Dichloroethane	3.5E-07	9.1E-02	B2	1	9E-02	3E-08
Inorganics:						
Arsenic	1.0E-07 (h)	1.75E+00	A	1	1.75E+00	2E-07
TOTAL						2E-07
Chemicals Exhibiting Noncarcinogenic Effects	RME Average Daily Dose (ADD) (mg/kg-day)	Reference Dose (mg/kg-day) [Uncertainty Factor] (e)	Target Organ or Critical Effect (f)	Absolute Oral Absorption Fraction (c)	Adjusted Reference Dose (mg/kg/day) (g)	RME ADD:RfD Ratio
MUNICIPAL WELLS =====						
Organics:						
Acetone	9.9E-07 (h)	1E-01 [1,000]	Kidney	0.83	8E-02	1.2E-05
Carbon disulfide	5.1E-05	1E-01 [100]	Fetotoxicity	1	1E-01	5.1E-04
4-Chloroaniline	1.0E-06 (h)	4E-03 [3,000]	Spleen	1	4E-03	2.6E-04
Chloroform	1.5E-05 (h)	1E-02 [1,000]	Liver	0.98	1E-02	1.5E-03
cis-1,2-Dichloroethene	1.2E-06 (h)	1E-02 [3,000]	Hematology	1	1E-02	1.2E-04
2-Methylphenol	1.7E-06 (h)	5E-02 [1,000]	Neurotoxicity	1	5E-02	3.4E-05
Inorganics:						
Arsenic	2.3E-07 (h)	3E-04 [3]	Skin	1	3E-04	7.8E-04
Barium	5.0E-06 (h)	7E-02 [3]	Inc. Blood Pressure	0.05	4E-03	1.4E-03
Chromium (total)	1.3E-08 (h)	5E-03 [500]	CNS	0.1	5E-04	2.7E-05
Manganese	5.5E-07 (h)	5E-03 [1]	CNS	0.055	3E-04	2.0E-03
Zinc	8.2E-07 (h)	3E-01 [3]	Blood Chemistry	0.3	9E-02	9.1E-06
HAZARD INDEX						< 1 (7E-03)
PRIVATE WELLS =====						
Organics:						
2-Methylphenol	3.1E-06 (h)	5E-02 [1,000]	Neurotoxicity	1	5E-02	6.2E-05
Inorganics:						
Chromium (total)	4.9E-08 (h)	5E-03 [500]	CNS	0.1	5E-04	9.8E-05
Copper	1.4E-06 (h)	3.7E-02 [1]	GI Irritation	0.97	4E-02	4.0E-05
Zinc	2.0E-05 (h)	3E-01 [3]	Blood Chemistry	0.3	9E-02	2.2E-04
HAZARD INDEX						< 1 (4E-04)

(a) Risks have been calculated for those chemicals of potential concern with oral toxicity criteria. The following chemicals are not presented due to lack of toxicity criteria: aluminum (Municipal Wells) and cobalt (Private Wells).

(b) USEPA Weight of Evidence for Carcinogenic Effects:

[A] = Human carcinogen based on adequate evidence from human studies.

[B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

(c) Absolute oral absorption fractions were obtained from the ATSDR toxicological profiles and U.S. EPA's IRIS and ECAO.

(d) Adjusted Slope Factor = Slope Factor/ Oral Absorption Fraction.

(e) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.

(f) A target organ or critical effect is the organ/effect most sensitive to the chemical exposure. RfDs are based on toxic effects in the target organ or critical effects. If an RfD is based on a study in which a target organ or critical effect was not identified, the organ/effect listed is one known to be influenced by the chemical.

(g) Adjusted Reference Dose = Reference Dose * Oral Absorption Fraction.

(h) Concentration used represents the maximum detected concentration.

TABLE 5-12

POTENTIAL RISKS ASSOCIATED WITH INHALATION BY ADULT RESIDENTS
OF VOLATILES EMITTED INTO AMBIENT AIR (a)

Chemicals Exhibiting Carcinogenic Effects	IEC Concentration (ug/m ³) (b)	Unit Risk (ug/m ³) ⁻¹	Weight of Evidence Class (c)	RME Upper Bound Excess Lifetime Cancer Risk
Organics:				
Benzene	4.5E-04	8.3E-06	A	3.8E-09
Chloromethane	1.9E-04	1.8E-06	C	3.5E-10
1,1-Dichloroethene	1.6E-04	5E-05	C	7.8E-09
Methylene chloride	2.7E-04	4.7E-07	B2	1.3E-10
Tetrachloroethene	2.4E-03	5.8E-07	C/B2	1.4E-09
Trichloroethene	9.0E-04	1.7E-06	C/B2	1.5E-09
Vinyl chloride	5.9E-03	8.4E-05	A	4.9E-07
TOTAL				5E-07

Chemicals Exhibiting Noncarcinogenic Effects	IEC Concentration (mg/m ³) (b)	Reference Concentration (RfC) (mg/m ³) [Uncertainty Factor] (d)	Target Organ or Critical Effect (e)	RME ADD:RfD Ratio
Organics:				
2-Butanone	1.0E-05	1E+00 [3,000]	Fetotoxicity	1.0E-05
Carbon disulfide	7.6E-07	1E-02 [1,000]	Fetotoxicity	7.6E-05
Chlorobenzene	2.1E-06	2E-02 [10,000]	Kidney/Liver	1.1E-04
Chloroethane	7.9E-07	1E+01 [300]	Fetotoxicity	7.9E-08
1,1-Dichloroethane	4.7E-07	5E-01 [1,000]	Kidney	9.5E-07
Ethylbenzene	1.1E-05	1E+00 [300]	Development	1.1E-05
Methylene chloride	6.4E-07	3E+00 [100]	Liver	2.1E-07
Toluene	5.7E-05	4E-01 [300]	CNS/Nasal	1.4E-04
HAZARD INDEX				< 1 (3E-04)

- (a) Risks are calculated for those chemicals of potential concern which readily volatilize and have toxicity criteria. The following chemicals are not presented due to lack of inhalation toxicity criteria: acetone, cis-1,2-dichloroethene, 4-ethyltoluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and xylenes.
- (b) Inhalation Exposure Concentrations are calculated by multiplying the air concentration by modifying factors. These modifying factors applied to the risk calculation include exposure frequency adjustment (350 days/365 days) for all chemicals and exposure duration adjustment only for carcinogens (30 years/70 years).
- (c) USEPA Weight of Evidence for Carcinogenic Effects:
 [A] = Human carcinogen based on adequate evidence from human studies.
 [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
 [C] = Possible human carcinogen based on limited evidence from animal studies.
- (d) Uncertainty factors represent the amount of uncertainty in extrapolation from the available data.
- (e) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by the particular chemical of concern.

TABLE 5-13

ESTIMATED DERMAL EXPOSURE AND POTENTIAL INCIDENCE OF SKIN CANCER
BY DERMAL CONTACT WITH CARCINOGENIC PAHS

Carcinogenic PAHs	Exposure Point Concentration (ug/kg)	Estimated Dermal Exposure (ug/cm ² -day) (a)	Estimated Dermal Exposure (ug/cm ²) (b)	Potential Risk of Skin Cancer (c)
CURRENT LAND-USE				
On-Site Surface Soil Child/Teenager Trespasser (6-16 yrs)				

Benzo(b)fluoranthene	110	1.1E-04	4.7E-03	Not likely (d)
Carbazole	130	1.3E-04	5.6E-03	Not likely (e)
Sediment Child/Teenager Trespasser (6-16 yrs)				

Benzo(a)anthracene	250	2.5E-04	8.8E-03	Not likely (f)
Benzo(a)pyrene	290	2.9E-04	1.0E-02	Not likely (g)
Benzo(b)fluoranthene	430	4.3E-04	1.5E-02	Not likely (d)
Chrysene	300	3.0E-04	1.0E-02	Not likely (e)

(a) See Section 4.4 for a description of the equation used to estimate the dermal exposure.

(b) Dermal exposure (ug/cm²) estimated by multiplying dermal exposure (ug/cm²-day) by the number of days/year exposed.

(c) Estimated dermal exposures were compared to experimental skin painting studies of mice which determined the incidence of skin tumors associated with dose ranges of CPAHs.

(d) Based on comparison to skin cancer incidences reported by LaVoie et al. (1982) and Habs et al. (1980).

(e) Data not available to evaluate this CPAH. Conclusion based on relative comparison to concentrations of other PAHs which cause skin cancer.

(f) Based on comparison to skin cancer incidence reported by Bingham and Falk (1969).

(g) Based on comparison to skin cancer incidence reported by LaVoie et al. (1982), Bingham and Falk (1969), Wislocki et al. (1977), Kapitulnik et al. (1976), Levin et al. (1976, 1977), and Habs et al. (1980).

TABLE 5-14
SUMMARY OF RISK ASSESSMENT RESULTS
H.O.D. LANDFILL

EXPOSURE PATHWAY	RME EXCESS LIFETIME CANCER RISK	PREDOMINANT CHEMICALS (a)	RME HAZARD INDEX	PREDOMINANT CHEMICALS (b)
CHILD/TEENAGE SITE TRESPASSER				
<i>Incidental surface soil ingestion</i>	4E-09	NA	<1 (7E-05)	NA
Dermal absorption from surface soil	5E-09	NA	<1 (1E-04)	NA
Dermal contact with surface water	NE	NA	<1 (5E-03)	NA
Incidental sediment ingestion	1E-08	NA	<1 (2E-04)	NA
Dermal absorption from sediment	4E-11	NA	<1 (1E-05)	NA
Direct contact with carcinogenic PAHs				
Surface soil	Cancer risk not likely	NA	NA	NA
Sediment	Cancer risk not likely	NA	NA	NA
NEARBY ADULT RESIDENT				
Ingestion of groundwater				
Off-site surficial sand	5E-05	Beryllium	>1 (6)	Manganese
Off-site deep sand and gravel	8E-04	Vinyl Chloride	<1 (9E-01)	NA
Municipal wells	9E-05	Arsenic	<1 (5E-01)	NA
Private wells	NE	NA	<1 (8E-02)	NA
NEARBY ADULT RESIDENT (Cont.)				
Inhalation of volatiles while showering				
Off-site deep sand and gravel	6E-05	Vinyl Chloride	NE	NA
Municipal wells	5E-07	NA	<1 (2E-03)	NA
Dermal absorption while showering				
Off-site surficial sand	2E-05	Beryllium	<1 (2E-01)	NA
Off-site deep sand and gravel	3E-05	Vinyl Chloride	<1 (4E-02)	NA
Municipal wells	2E-07	NA	<1 (7E-03)	NA
Private wells	NE	NA	<1 (4E-04)	NA
Inhalation of volatiles from ambient air	5E-07	NA	<1 (3E-04)	NA

NA = Not applicable.

NE = Not evaluated since chemicals relevant for this health endpoint were not selected or detected in this data grouping.

(a) Predominant chemicals are those with RME cancer risk greater than 1E-06 (1 in 1,000,000).

(b) Predominant chemicals are those with RME hazard quotients greater than 1.

TABLE 6-1

**COMPARISON OF MEASURED SURFACE WATER CONCENTRATIONS TO
USEPA AMBIENT WATER QUALITY CRITERIA (AWQC) OR
LOWEST-OBSERVED-EFFECT-LEVELS (LOELs)**

(Concentrations reported in ug/L)

Chemical (a)	Guidance Value (b)	Sequoit Creek (c)		On-Site Leachate (c)	
		Mean	Maximum	Mean	Maximum
Organics:					
Aroclor 1260	0.014	--	--	1.5	5.5
Benzene	5300 *@	--	--	17	22
1,4-Dichlorobenzene	763 * (d)	--	--	10	20
1,1-Dichloroethane	20,000 * (e)	--	--	13	13
1,2-Dichloroethane	20,000 *	--	--	17	22
1,1-Dichloroethene	11,600 * @ (f)	--	--	NA	5
1,2-Dichloroethene	11,600 * @ (f)	--	--	100	190
1,2-Dichloropropane	5,700 * (g)	--	--	23	28
Diethylphthalate	3 * (h)	--	--	14	32
2,4-Dimethylphenol	530 (P)	--	--	8.9	20
Ethylbenzene	32,000 *@	--	--	77	130
bis(2-ethylhexyl) phthalate	3 * (h)	--	--	21	42
Naphthalene	620 *	--	--	17	30
Phenol	2,560 *	--	--	220	840
Tetrachlorethene	840 *	--	--	9	9
Toluene	17,500 * @	--	--	330	740
Trichloroethene	21,900 *	--	--	13	14
Inorganics:					
Aluminum	87	< BKG	< BKG	46,000	140,000
Antimony	30	14	20	--	--
Arsenic	190	--	--	31	51
Beryllium	5.3 *	--	--	3.3	8.3
Cadmium	1.1 +	--	--	19	45
Chromium	11 (i)	--	--	110	270
Copper	12 +	< BKG	< BKG	190	480

TABLE 6-1 (continued)

COMPARISON OF MEASURED SURFACE WATER CONCENTRATIONS TO
USEPA AMBIENT WATER QUALITY CRITERIA (AWQC) OR
LOWEST-OBSERVED-EFFECT-LEVELS (LOELs)

(Concentrations reported in ug/L)

Chemical (a)	Guidance Value (b)	Sequoit Creek (c)		On-Site Leachate (c)	
		Mean	Maximum	Mean	Maximum
Cyanide	5.2	--	--	10	38
Iron	1,000	190	420	140,000	380,000
Lead	3.2 +	0.91	1.5	540	1,900
Mercury	0.012	--	--	0.76	1.3
Nickel	160 +	--	--	170	370
Silver	0.12	--	--	3.9	8.2
Zinc	110 +	--	--	1,700	4,700

@ = acute value.

* = LOEL

+ = hardness-dependent criterion; 100 mg CaCO₃/l assumed.

(P) = proposed criterion.

■ = concentration above guidance value

-- = chemical was not detected in these samples.

<BKG = chemical was detected but concentration was not statistically different from background.

- (a) Chemicals listed are those that were detected in site water samples at concentrations above background concentrations and for which USEPA has published AWQCs or LOELs (USEPA 1986).
- (b) Value is chronic ambient water quality criterion (AWQC) for the protection of freshwater aquatic life, unless otherwise noted.
- (c) Arithmetic mean and maximum detected concentrations.
- (d) Value is for dichlorobenzenes.
- (e) Value is for 1,2-dichloroethane.
- (f) Value is for dichlorethenes.
- (g) Values is for dichloropropanes/propenes.
- (h) Value is for phthalate esters.
- (i) Value is for hexavalent chromium.

TABLE 6-2

COMPARISON OF MEASURED CHEMICAL CONCENTRATIONS IN
SEQUOIT CREEK SEDIMENT TO SEDIMENT GUIDANCE VALUES

Chemical (a)	Guidance Value (b)		Sequoit Creek Concentrations	
	ER-L	ER-M	Mean	Maximum
Organics (Concentrations in ug/kg):				
Benzo(a)anthracene	261	1600	NA	250
Benzo(a)pyrene	430	1600	NA	290
Chrysene	384	2800	NA	300
Fluoranthene	600	5100	530	680
Pyrene	665	2600	470	580
Inorganics (Concentrations in mg/kg)				
Arsenic	8.2	70	6.2	7.2

= concentration exceeds the ER-L.

- (a) Chemicals listed are those that were detected in Sequoit Creek sediment samples at concentrations above background and for which sediment screening values are available.
- (b) Values from Long and MacDonald (1992). Effects range-low (ER-L) and effects range-median (ER-M) correspond to the lower 10th and 50th percentile, respectively, of sediment values known or known or estimated to be associated with some type of toxic effect in aquatic species.

TABLE 6-3

SUMMARY OF POTENTIAL EXPOSURE PATHWAYS AND RISKS
FOR ECOLOGICAL RECEPTORS
H.O.D. LANDFILL SITE

Exposure Medium	Receptor	Exposure Pathway	Potential for Exposure	Risk
Surface water	Aquatic life	Respiration, dermal absorption, ingestion of chemicals that have been released to surface water via groundwater discharge, surface transport of leachate from seepage areas, and surface runoff of soil-sorbed chemicals.	High. Surficial groundwater containing chemicals of potential concern does discharge to Sequit Creek. Leachate does discharge to the surface via isolated seeps. Surface drainage is towards Sequit Creek. Aquatic life inhabits the creek.	< Low. Few chemicals detected in Sequit Creek surface water. Of the inorganic chemicals detected, only antimony, lead, barium, and iron were present at concentrations that are potentially above background, and each of these was detected below concentrations likely to cause toxicity in aquatic species. 2-Hexanone and 4-methyl-2-pentanone were the only organic chemicals detected in surface water and were present at concentrations (2-3 µg/l) that are well below those likely to be associated with aquatic toxicity.
Surface water	Terrestrial wildlife	Ingestion or dermal absorption of chemicals that have been released to surface water via groundwater discharge, surface transport of leachate from seepage areas, and surface runoff of soil-sorbed chemicals. Ingestion of chemicals that have accumulated in aquatic prey.	High. Surficial groundwater containing chemicals of potential concern does discharge to Sequit Creek. Leachate does discharge to the surface via isolated seeps and drain toward Sequit Creek. Creek is likely a source of drinking water for some wildlife species. <<< Low. None of the chemicals of potential concern in surface water accumulates in aquatic prey to any appreciable degree.	< Low. Few chemicals detected in Sequit Creek surface water. Of those detected, none are present at concentrations that would be toxic to terrestrial species. <<< Low. <<< Low exposure potential and also low terrestrial wildlife toxicity of the chemicals of potential concern.
Sediment	Aquatic life	Ingestion or dermal absorption of chemicals that have been released via groundwater discharge, surface transport of leachate, and surface run-off of soil-sorbed chemicals.	High. Surficial groundwater containing chemicals of potential concern does discharge to Sequit Creek. Leachate does discharge to the surface via isolated seeps. Surface drainage is towards Sequit Creek. Aquatic life inhabits the creek.	< Low. Chemicals detected at concentrations that are below those expected to pose a risk to aquatic life.

TABLE 6-3 (continued)

SUMMARY OF POTENTIAL EXPOSURE PATHWAYS AND RISKS
FOR ECOLOGICAL RECEPTORS
H.O.D. LANDFILL SITE

Exposure Medium	Receptor	Exposure Pathway	Potential for Exposure	Risk
Sediment	Terrestrial wildlife	Ingestion of chemicals that have been released to surface water via groundwater discharge, surface transport of leachate from seepage areas, and surface runoff of soil-sorbed chemicals.	High. Surficial groundwater containing chemicals of potential concern does discharge to Sequoit Creek. Leachate does discharge to the surface via isolated seeps and drain toward Sequoit Creek. Creek is likely a source of drinking water for some wildlife species.	< Low. None of the chemicals detected in creek sediment are at concentrations likely to pose a risk to terrestrial wildlife.
		Ingestion of chemicals that have accumulated in aquatic prey.	<<< Low. None of the chemicals of potential concern in surface water accumulates in aquatic prey to any appreciable degree.	<<< Low. <<< Low exposure potential and also low terrestrial wildlife toxicity of the chemicals of potential concern.
Surface soil	Terrestrial wildlife	Direct ingestion of soil-sorbed chemicals while foraging or grooming. Dermal absorption of soil-sorbed chemicals in contact with skin (e.g., for soil-dwelling vertebrates and invertebrates).	Moderate. Landfill surface provides habitat for small mammals (e.g., mice, voles, shrews) and other terrestrial wildlife. Chemicals of potential concern have been detected in surface soils near seepage areas.	< Low. None of the chemicals of potential concern was detected at a concentration that is likely to pose a hazard to terrestrial species. The maximum concentrations of total PAHs and total volatiles of 2.8 mg/kg (SU02) and 1.3 mg/kg (SU01), respectively, are not likely to be associated with toxicological response.
		Ingestion of chemicals that have accumulated in terrestrial prey (e.g., earthworms, small mammals).	<<< Low. None of the chemicals of potential concern in soil accumulates in terrestrial species to any appreciable degree.	<<< Low. <<< Low exposure potential and also low toxicity of the chemicals of potential concern.
Soil	Terrestrial plants	Uptake through roots of chemicals present in soils.	High. Chemicals of potential concern have been detected in surface soils near seepage areas of the site. Vegetation occurs in these areas.	Low. Based on observations of the condition of plants near the largest leachate seep, local vegetation appears to be unaffected.

TABLE 6-3 (continued)

SUMMARY OF POTENTIAL EXPOSURE PATHWAYS AND RISKS
FOR ECOLOGICAL RECEPTORS
H.O.D. LANDFILL SITE

Exposure Medium	Receptor	Exposure Pathway	Potential for Exposure	Risk
Air	Terrestrial wildlife	Inhalation of chemicals that volatilize from the landfill surface/subsurface or from surface water following groundwater discharge to surface water.	Moderate for soil-dwelling species. Volatile chemicals are present in landfill gas and vertebrate and invertebrate wildlife occupy the landfill surface. Low for other terrestrial wildlife species. Dispersion and dilution would result in negligible exposures in wildlife using the landfill surface or the area of groundwater discharge.	Low. Chemical concentrations in landfill gas are below those likely to be associated with toxic effects. < Low. Low exposure potential and the relatively low toxicity of the volatile chemicals of potential concern combine to create a low risk level.
Air	Terrestrial plants	Stomatal uptake of airborne chemicals.	High. Volatile chemicals have been detected in landfill gas. Vegetation covers the landfill surface.	Low. Based on observations of the condition of plants on the landfill, local vegetation appears to be unaffected.
Leachate	Terrestrial wildlife	Ingestion of leachate or incidental ingestion of soil while drinking from surface seeps.	Low. Wildlife exposure expected to be limited because surface seeps flow only intermittently and other sources of drinking water are accessible and prevalent in the surrounding area.	Low. Low exposure potential combined with low leachate chemical concentrations relative to those expected to be toxic following intermittent exposure.
Leachate	Terrestrial invertebrates (larval insects)	Respiration, dermal absorption, ingestion of chemicals present in surface leachate.	High. Surface seeps exist on the landfill surface. Leachate likely contains chemicals. Plants occur in seepage areas. Insects and other invertebrates might use seeps as seasonal breeding areas.	Low. Toxic effects could occur at seeps, but overall impact on the invertebrate community of the area will be low given the size of the seeps relative to other available habitat in the area.
Leachate	Terrestrial plants	Uptake through roots and leaves of chemicals present in surface leachate.	High. Surface seeps exist on the landfill surface. Leachate likely contains chemicals. Plants occur in seepage areas.	Low. Based on observations of the condition of plants near the largest leachate seep, local vegetation appears to be unaffected.

TABLE 7-1

UNCERTAINTIES IN THE BASELINE RISK ASSESSMENT
FOR THE H.O.D. LANDFILL RISK ASSESSMENT

ENVIRONMENTAL SAMPLING AND ANALYSIS AND SELECTION OF CHEMICALS

Assumption	Magnitude of Effect on Risk ^a	Direction of Effect on Risk
Systematic or random errors in the chemical analysis may yield erroneous data	Low	May over- or under-estimate risk
When fewer than 3 samples were available, or no background data were available for a chemical, it was selected as a chemical of potential concern by default	Low	May overestimate risk
Regional background data were used to select chemicals of potential concern in soil and groundwater	Low	May over- or under-estimate risk
A comparison to background was not performed for organics in selecting chemicals	Low	May overestimate risk

^aKey: Low \leq 1 order of magnitude effect.
 Moderate \geq 1 to \leq 2 orders of magnitude effect.
 High \geq 2 orders of magnitude effect.

TABLE 7-2
 UNCERTAINTIES IN THE BASELINE RISK ASSESSMENT
 FOR THE H.O.D. LANDFILL RISK ASSESSMENT
 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS

Assumption	Magnitude of Effect on Risk ^a	Direction of Effect on Risk
Environmental concentrations were based on data available from the RI	Low	May over- or under-estimate risk
Chemical concentrations reported as non-detected were included as one-half of the detection limit in calculating concentrations	Low	May over- or under-estimate risk
The 95% upper confidence limit on the population mean or maximum (whichever was lower) was used as the exposure point concentration	Low - High	May overestimate risk
Concentrations resulting from volatilization and dispersion of chemicals from the landfill surface were calculated using environmental fate and transport models	Low-Moderate	May over- or under-estimate risk
Concentrations in shower-room air were calculated using environmental fate and transport models	Low	May over- or under-estimate risk

^aKey: Low \leq 1 order of magnitude effect.
 Moderate \geq 1 to \leq 2 orders of magnitude effect.
 High \geq 2 orders of magnitude effect.

TABLE 7-3

UNCERTAINTIES IN THE BASELINE RISK ASSESSMENT
FOR THE H.O.D. LANDFILL RISK ASSESSMENT

ESTIMATION OF CHEMICAL DOSES

Assumption	Magnitude of Effect on Risk ^a	Direction of Effect on Risk
Exposures were assumed to occur on a regular basis for each selected pathway	Low - High	May overestimate risk
Default USEPA assumptions regarding body weight, duration of exposure, and life expectancy may not be representative for the site area population	Low	May over- or under-estimate risk
Exposures were estimated assuming no migration of residents out of the facility area for 30 years	Low	May over- or under-estimate risk
The dermal absorption of chemicals from soils/sediment through skin was based on data from experimental studies	Low - Moderate	May over- or under-estimate risk
The dermal absorption of chemicals from surface water through skin was based on experimental studies or an equation derived by USEPA (1992a)	Low - Moderate	May over- or under-estimate risk
Dermal doses for organic chemicals in surface water were calculated using USEPA's (1992a) nonsteady-state approach	Low - Moderate	May overestimate risk

^aKey: Low \leq 1 order of magnitude effect.
 Moderate \geq 1 to \leq 2 orders of magnitude effect.
 High \geq 2 orders of magnitude effect.

TABLE 7-4
 UNCERTAINTIES IN THE BASELINE RISK ASSESSMENT
 FOR THE H.O.D. LANDFILL RISK ASSESSMENT
 TOXICITY ASSESSMENT

Assumption	Magnitude of Effect on Risk ^a	Direction of Effect on Risk
Quantitative toxicity criteria were not available for all of the selected chemicals of potential concern	Low	May underestimate risk
Cancer slope factors derived from animal studies are based on upper 95th percentile confidence limits derived from the linearized mult-stage model	Moderate - High	May overestimate risk
There are uncertainties in the design, extrapolation and interpretation of toxicological experimental studies	Low - Moderate	May overestimate risk
Cancer risks were added across chemicals with different USEPA weight-of-evidence classifications (e.g., adding risks for a Group A and Group B2 carcinogens)	Moderate	May overestimate risk
Conservatively derived reference doses were used to assess risks	Low - Moderate	May overestimate risk
Risks were assumed to be additive although they may potentially be synergistic or antagonistic	Moderate	May over- or under-estimate risk
For inhalation pathways, unit risks and reference concentrations were used, with no adjustments for potential differences in ventilation rate or body weight for the exposure scenario evaluation	Low - Moderate	May over- or under-estimate risk

^aKey: Low \leq 1 order of magnitude effect.
 Moderate \geq 1 to \leq 2 orders of magnitude effect.
 High \geq 2 orders of magnitude effect.

APPENDIX A

APPENDIX A

SHOWER MODEL

APPENDIX A

A.1 SHOWER MODEL

Volatile organic chemicals (VOCs) dissolved in household water supplies can be released into the indoor air as a result of showering, bathing, dishwashing, laundering and cooking. Of particular concern to human health is the potential for elevated exposures to occur in the confined space of a shower. The shower model developed by Foster and Chrostowski (1987) was used to assess the possible inhalation exposures to VOCs from groundwater at the H.O.D. Landfill site. The use of this model was approved by USEPA Region V as part of the Technical Workplan for H.O.D. Landfill for the Baseline Risk Assessment. In the shower model, inhalation exposures are modeled by estimating the rate of chemical release into the air (generation rate), the buildup (shower on) and decay (shower off) of VOCs in shower room air, and the resulting time-weighted average VOC concentrations for the duration of shower room exposure.

The chemical-specific parameters used in the shower model are shown in Table A-1. The physical parameters describing the shower environment used in the model are shown in Table A-2.

Discussion of Uncertainties

As noted in the original paper (Foster and Chrostowski 1987), the shower model was validated by comparison to measured data (Andelman 1985). Depending on the time, the model underestimates air-borne levels by a factor of up to about 6%. Based on a review of several shower models, McKone (1987) identified a range of inhalation-to-ingestion doses of 0.24 to 6 for VOCs, compared to the range of 1.1 to 2.0 derived by McKone (1987) from Foster and Chrostowski (1987). More recently, Jo et al. (1990a) corroborated, using measurements in exhaled breath, that total chloroform exposures from showering resulted in doses which were comparable to those calculated using the Foster and Chrostowski (1987) model. Jo et al. (1990b) found, however, that approximately one-half the total chloroform dose resulted from dermal exposure while showering. Taking all of these results into account, the Foster and Chrostowski (1987) model used in this assessment appears to yield reasonably accurate predictions of exposure while showering.

TABLE A-1
CHEMICAL-SPECIFIC PARAMETERS

Chemical	Molecular Weight (g/mole)	Henry's Law Constant (atm-m ³ /mole) (a)
1,2-Dichloroethane	98.96	1.22E-03
1,2-Dichloroethene	96.94	6.60E-03 (b)
Acetone	58.08	3.67E-05 (d)
Carbon disulfide	76.14	1.40E-03 (c)
Chloroform	119.39	3.14E-03
Vinyl chloride	62.5	5.68E-02

Notes:

- (a) Values from Mackay et al. (1993).
- (b) Henry's law constant for trans-1,2-dichloroethene.
- (c) Calculated from solubility and vapor pressure (Howard 1990).
- (d) Rathbun and Tai (1982).

TABLE A-2

PHYSICAL INPUT PARAMETERS TO THE SHOWER MODEL

Parameter	Value
Shower water temperature (T_s)	318 K
Water viscosity at shower temperature (μ_s)	0.596 cp
Shower droplet drop time (t)	2 sec.
Shower droplet diameter (d)	1 mm
Shower water flow rate (Fr)	10 L/min.
Air exchange rate in shower room (R)	0.083/min.
Shower duration (D_s)	12 min.
Duration in shower room after shower stops	5 min.
Calibration H_2O temperature (T_1)	293 K
Water viscosity at T_1 (μ_1)	1.002 cp
Shower room air volume (S_v)	6 m ³

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APPENDIX B

LANDFILL GAS EMISSIONS AND DISPERSION MODELING

B.1 LANDFILL GAS EMISSIONS AND DISPERSION MODELING

Mathematical modeling was conducted to predict emission rates of volatile organic compounds (VOCs) from the landfill surface, and the resulting ambient air concentrations at the property boundaries. The modeling employed standard screening-level algorithms for both the emissions and dispersion components. Screening-level models provide upper-bound estimates of ambient air concentrations. The remainder of this Appendix provides an overview of the models and input values used for this analysis. The emission rates for VOCs from the landfill surface were based on a model presented by Karimi et al. (1987) that describes the emissions as a diffusion controlled process using Fick's First Law for steady-state diffusion. The VOC emission rates were calculated as:

$$J = \frac{D_o * \left(\frac{P_a^{10/3}}{P_t^2} \right) (C_s - C_2)}{L} \quad (1)$$

where:

J	=	flux rate from landfill surface, g/m ² -s;
D _o	=	diffusion coefficient in air, m ² /s;
P _a	=	air-filled porosity, 0.10 m ³ /m ³ ;
P _t	=	total soil porosity, 0.25 m ³ /m ³ ;
C _s	=	soil gas concentration, g/m ³ ;
C ₂	=	gas concentration at soil-air interface, g/m ³ ;
L	=	thickness of landfill cover, 1.58 m.

In this evaluation the concentration of the volatilizing material at the landfill surface (C₂) was set equal to zero. This follows the assumption used by Karimi et al. (1987) and implies an upper-bound estimate of the flux rate, as any increase in C₂ effectively reduces the concentration gradient across the landfill cover and the resulting flux from the landfill cell. Porosity measurements for the landfill cover soil were not available, however, the soil has been characterized as a clay. From published literature for clay soils an average total porosity of 50% was identified. Because the clay soil had been compacted to form the landfill surface, the total porosity was reduced to 25%. It was assumed that the air-filled porosity could range from 1-20%, with a midpoint of roughly 10% (Walton 1987). The landfill cover thickness, L, was set at 1.58 m based on site-specific data. The soil gas concentration at the bottom of the landfill cover, C_s, was assumed to be equal to the mean on-site landfill gas measurements collected during the remedial investigation.

The ambient air concentrations associated with the VOC flux rates were calculated using a box model. The steady-state box model assumes that the ambient air concentration is a balance between the emission rate (g/s) and the volumetric flow rate (m³/sec) of air through the box. The flux rate calculated in Equation 1 was converted to an emission rate using the combined surface area of the old and new landfills (195,097 m²). The volumetric flow rate of air through the box was described by the surface area and height of the box, along with the steady-state wind speed. The surface area of the box was calculated as the limits of the property boundary. The box height was calculated using the following expression for the mean vertical displacement of emissions as a function of downwind distance for a neutral atmosphere, as given by Pasquill (1975):

$$x = 6.25 * Z_o \left[\left(\frac{H}{Z_o} \right) \ln \left(\frac{H}{Z_o} \right) - 1.58 \left(\frac{H}{Z_o} \right) + 1.58 \right] \quad (2)$$

where:

x = downwind distance of box, 823 m;
 Z_o = roughness height of surface, 0.1 m.

Using the values of x and Z_o in Equation 2, the associated value of H, the box model height was found to be 31.52 m. The value for the surface roughness height, Z_o, was selected to represent a surface with low grass and occasional large obstacles (NOAA 1983). The ambient air concentrations were then found using the following equation:

$$C_a = \frac{J * A}{W * H * U} \quad (3)$$

where:

J = flux rate from Equation 1, g/m²-s;
 A = area of landfill surface, 195,097 m²;
 W = crosswind width of box, 366 m;
 H = height of box at property boundary, 31.5 m;
 U = windspeed in box, 4.65 m/s.

The windspeed through the box was obtained from the annual average windspeed observed at the National Weather Service's station at Chicago's O'Hare International Airport. It should be noted that the property boundaries used for the box model were not square, (366 m by 823 m). Therefore, the

selection of which value to use for the downwind and crosswind distance will have an impact on the model predictions. For the purposes of this analysis, the values which resulted in the highest model predictions were used. Thus, the model predicted concentrations are approximately 15% higher than would result from reversing the values for the crosswind and downwind distances.

The emissions and dispersion modeling for the landfill gas was based on steady-state models, and therefore represents long-term averages. The use of the annual average windspeed in the box model equation makes the resulting concentrations a reasonable estimate of the annual average exposures at the property boundaries. Use of more refined models and more site-specific input values would likely result in lower predictions of annual average ambient air concentrations. Table 1 presents the input parameters and results of the modeling for this scenario.

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TABLE B-1

EMISSION AND DISPERSION MODEL INPUTS AND RESULTS

Chemical	Molecular Weight (g/mol)	Mean Landfill Gas Concentrations		Diffusivity in Air (m ² /sec)	Flux Rate (g/m ² -sec)	Emission Rate (g/s)	Ambient Air Concentration (g/m ³)
		(ppbv)	(ug/m ³)				
Acetone	58.1	4,100	9,909	1.2E-05	2.07E-09	4.04E-04	7.53E-09
Benzene	78.0	550	1,785	9.3E-06	3.02E-10	5.89E-05	1.10E-09
2-Butanone	72.1	5,900	17,695	8.9E-06	2.87E-09	5.60E-04	1.04E-08
Carbon Disulfide	76.1	400	1,266	9.4E-06	2.17E-10	4.23E-05	7.89E-10
Chlorobenzene	112.6	1,000	4,684	7.2E-06	6.12E-10	1.19E-04	2.22E-09
Chloroethane	65.0	450	1,217	1.0E-05	2.25E-10	4.40E-05	8.20E-10
Chloromethane	51.0	290	615	1.2E-05	1.28E-10	2.51E-05	4.67E-10
1,1-Dichloroethane	99.0	220	906	8.3E-06	1.36E-10	2.65E-05	4.95E-10
1,1-Dichloroethene	97.0	170	686	8.4E-06	1.04E-10	2.03E-05	3.79E-10
cis-1,2-Dichloroethene	97.0	2,000	8,066	8.4E-06	1.22E-09	2.39E-04	4.45E-09
Ethylbenzene	116.0	5,600	27,022	6.7E-06	3.27E-09	6.39E-04	1.19E-08
Methylene Chloride	84.9	320	1,131	8.9E-06	1.83E-10	3.58E-05	6.67E-10
Tetrachloroethane	165.9	1,700	11,728	7.4E-06	1.58E-09	3.07E-04	5.73E-09
Toluene	92.2	30,000	114,996	7.8E-06	1.64E-08	3.19E-03	5.95E-08
Trichloroethene	131.4	850	4,646	7.2E-06	6.06E-10	1.18E-04	2.20E-09
1,2,4-Trimethylbenzene	120.2	820	4,100	7.5E-06	5.59E-10	1.09E-04	2.03E-09
1,3,5-Trimethylbenzene	120.2	360	1,800	7.5E-06	2.45E-10	4.79E-05	8.93E-10
Vinyl Chloride	62.5	8,000	20,799	1.0E-05	3.93E-09	7.66E-04	1.43E-08
Xylenes (total)	106.2	14,000	61,829	7.2E-06	8.04E-09	1.57E-03	2.92E-08

APPENDIX C

SUMMARY OF CALCULATIONS USED TO QUANTIFY EXPOSURES (AVERAGE DAILY DOSES AND INHALATION EXPOSURE CONCENTRATIONS)

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APPENDIX C

SUMMARY OF CALCULATIONS USED TO QUANTIFY EXPOSURES (AVERAGE DAILY DOSES AND INHALATION EXPOSURE CONCENTRATIONS)

C.1 INTRODUCTION

This appendix presents the equations used to derive quantitative estimates of exposure for each exposure pathway selected for detailed evaluation. The approach used in this section is consistent with guidance produced by the U.S. Environmental Protection Agency (USEPA 1986, 1989, 1992a). The specific equations for each pathway are presented in the following sections.

For the inhalation pathways, exposures were quantified by deriving inhalation exposure concentrations (IECs), expressed as air concentrations ($\mu\text{g}/\text{m}^3$). In assessing inhalation exposures, IECs were compared to inhalation toxicity criteria, similarly expressed as air concentration or reciprocal air concentrations. IECs were derived by applying modifying factors to the exposure point concentrations estimated in air; these factors were applied to account for the differences in exposure assumptions made under the various pathways and used by USEPA in deriving inhalation toxicity criteria. As constant exposure for a lifetime (carcinogens) or for the entire duration of exposure (noncarcinogens) is assumed by USEPA in deriving inhalation toxicity criteria, the modifying factors applied to the exposure point concentrations when deriving IECs pertained to exposure time (hours/day), exposure frequency (days/year), and exposure duration (years, carcinogens only).

For the pathways which involve ingestion or dermal contact, quantification of exposure involves calculation of an average daily dose in units of mg chemical/kg body weight-day (mg/kg-day). For ingestion or dermal pathways, dose can be defined as an exposure rate to a chemical determined over an exposure period per unit body weight. However, there is a significant difference in the meaning and terms used to describe dose for the ingestion and dermal pathways. For the oral pathways of exposure, the doses calculated in this assessment are referred to as "potential doses." The potential dose is the amount of chemical ingested and available for uptake, and is analogous to the administered dose in a dose-response experiment. For the dermal absorption pathways, the dose is referred to as an "internal dose," and it reflects the amount of chemical that has been absorbed into the body and is available for interaction with biologically important tissues.

The general equation for potential dose (D_{pot}) is the integration of the chemical intake rate:

$$D_{pot} = \int_{t_1}^{t_2} C(t) IR(t) dt$$

where $C(t)$ is time-dependent concentration of the chemical in the medium of concern, and $IR(t)$ is the human intake rate of that medium. The quantity $t_2 - t_1$ represents the period of time over which exposure is being examined, or the exposure duration (ED).

The dose equation can also be expressed in discrete form as a summation of the doses received during various events i:

$$D_{pot} = \sum_i C_i * IR_i * ED_i$$

If C and IR do not vary considerably, D_{pot} may be expressed as averages:

$$D_{pot} = \bar{C} * \bar{IR} * ED$$

where C and IR are averaged over the exposure duration and ED summed over all events. An internal dose (D_{int}) for dermal absorption pathways may be calculated in a fashion similar to D_{pot} with variables describing uptake rate used in lieu of IR (intake rate).

An average daily dose is estimated by averaging D_{pot} or D_{int} over body weight and an averaging time. For noncarcinogens, the averaging time is the exposure duration, following USEPA (1992a) guidance, and is referred to as an average daily dose (ADD_{pot} or ADD_{int}). For carcinogens, the averaging time is a 70-year lifetime, and is referred to as a lifetime average daily dose ($LADD_{pot}$ or $LADD_{int}$).

C.2 INGESTION OF GROUNDWATER

The potential dose of each carcinogenic chemical of concern associated with ingestion of groundwater as drinking water was calculated using the following equation:

$$LADD_{pot} = \frac{Cw * IR * EF * ED}{BW * LT}$$

where

$LADD_{pot}$ = potential lifetime average daily dose (mg/kg-day),

Cw	=	chemical concentration in groundwater (mg/l),
IR	=	water ingestion rate (l/day),
EF	=	frequency of exposure (days/year),
ED	=	duration of exposure (years),
BW	=	average body weight (kg), and
LT	=	number of days in a lifetime of 70 years (70 years * 365 days/year).

For each noncarcinogen, the potential dose associated with groundwater ingestion was calculated as follows:

$$ADD_{pot} = \frac{Cw * IR * EF * ED}{BW * AT}$$

where

ADD _{pot}	=	potential average daily dose (mg/kg-day), and
AT	=	averaging time = exposure duration (ED) in days.

C.3 INHALATION OF VOLATILE ORGANICS WHILE SHOWERING OR FROM LANDFILL EMISSIONS

Exposures associated with inhalation of volatile organic chemicals released while showering or released from the landfill are calculated using the following equation:

$$IEC = Ca * \frac{ET}{24} * \frac{EF}{365} * \frac{ED}{AT}$$

where

IEC	=	inhalation exposure concentration (μg/m ³),
Ca	=	chemical concentration in shower room air or ambient air (μg/m ³),
ET	=	shower room exposure time (shower duration plus time spent in shower room after showering) (hours/day) or ambient exposure time (24 hours/day),
EF	=	exposure frequency (days/year),
ED	=	duration of exposure (years), and
AT	=	averaging time (70 year lifetime for carcinogens, duration of exposure for noncarcinogens).

Note that IECs are calculated differently for chemicals exhibiting carcinogenic versus noncarcinogenic effects. In the former case, exposure is extrapolated over a lifetime while in the latter case, IECs are estimated over the actual duration of exposure.

C.4 INCIDENTAL INGESTION OF SOIL OR SEDIMENT

Chemical doses associated with the incidental ingestion of surface soil or sediment were estimated for carcinogens using the following equation:

$$LADD_{pot} = \frac{Cs \cdot IR \cdot FI \cdot EF \cdot ED \cdot Bio \cdot CF \cdot TEF}{BW \cdot LT}$$

where

LADD _{pot}	=	potential lifetime average daily dose (mg/kg-day),
Cs	=	chemical concentration in soil (mg/kg),
IR	=	soil ingestion rate (mg/day),
FI	=	fraction ingested from contaminated source (unitless),
EF	=	frequency of exposure (days/year),
ED	=	duration of exposure (years),
Bio	=	Relative oral bioavailability factor to adjust for matrix effects (unitless),
TEF	=	toxic equivalency factor for carcinogenic PAHs (unitless),
CF	=	conversion factor (1 kg/10 ⁶ mg),
BW	=	average body weight (kg), and
LT	=	number of days in a lifetime of 70 years (70 years * 365 days/year).

For noncarcinogens, potential doses associated with ingestion of surface soil or sediment were calculated as follows:

$$ADD_{pot} = \frac{Cs \cdot IR \cdot FI \cdot EF \cdot ED \cdot Bio \cdot CF}{BW \cdot AT}$$

where

ADD _{pot}	=	potential average daily dose (mg/kg-day), and
AT	=	averaging time = exposure duration (ED) in days.

The relative oral bioavailability factor (Bio) represents the ratio of a chemical's bioavailability (i.e., ability to be absorbed and potentially exert an effect) when administered in an environmental matrix relative to its bioavailability when administered in the experimental dose-exposure study from which the toxicity

criteria for that chemical was derived. The relative oral bioavailability factor can be applied to account for the reduced bioavailability of chemicals when associated with a soil or sediment matrix compared to when administered in a food mash, water or a solvent medium.

C.5 DERMAL ABSORPTION OF CHEMICALS FROM SOIL OR SEDIMENT

Internal doses associated with dermal contact with carcinogenic chemicals of potential concern in surface soil or sediment were calculated using the equation below:

$$LADD_{int} = \frac{DA \cdot SA \cdot EV \cdot EF \cdot ED}{BW \cdot LT}$$

where

LADD _{int}	=	internal lifetime average daily dose (mg/kg-day),
DA	=	dose absorbed per unit area per event (mg/cm ² -event),
SA	=	skin surface area available for contact (cm ²),
EV	=	event frequency (events/day),
EF	=	frequency of exposure (days/year),
ED	=	duration of exposure (years),
BW	=	average body weight (kg), and
LT	=	number of days in a lifetime of 70 years (70 years * 365 days/year).

For noncarcinogens, internal doses associated with dermal absorption from soil or sediment were calculated as follows:

$$ADD_{int} = \frac{DA \cdot SA \cdot EV \cdot EF \cdot ED}{BW \cdot AT}$$

where

ADD _{int}	=	internal average daily dose (mg/kg-day), and
AT	=	averaging time = exposure duration (ED) in days.

For both carcinogens and noncarcinogens, the dose absorbed per unit area per event (DA) is calculated as follows:

$$DA = Cs \cdot CF \cdot AF \cdot Abs$$

where

DA	=	dose absorbed per unit area per event (mg/cm ² -event),
----	---	--

Cs	=	chemical concentration in soil (mg/kg),
CF	=	conversion factor (1 kg/10 ⁶ mg),
AF	=	soil-to-skin adherence factor (mg/cm ² -event), and
Abs	=	dermal absorption fraction (unitless).

C.6 DERMAL ABSORPTION OF CHEMICALS FROM WATER

Doses estimated for dermal absorption of carcinogenic chemicals of potential concern in water were calculated using the equation below:

$$LADD_{int} = \frac{DA \cdot SA \cdot EV \cdot EF \cdot ED}{BW \cdot LT}$$

where

LADD _{int}	=	internal lifetime average daily dose (mg/kg-day),
DA	=	dose absorbed per unit area per event (mg/cm ² -event),
SA	=	skin surface area available for contact (cm ²),
EV	=	event frequency (events/day)
EF	=	frequency of exposure events (days/year),
ED	=	duration of exposure (years),
BW	=	average body weight (kg), and
LT	=	number of days in a lifetime of 70 years (70 years * 365 days/year).

The internal dose for each noncarcinogenic chemical in water was calculated as follows:

$$ADD_{int} = \frac{DA \cdot SA \cdot EV \cdot EF \cdot ED}{BW \cdot AT}$$

where

ADD _{int}	=	internal average daily dose (mg/kg-day), and
AT	=	averaging time = exposure duration (ED) in days.

DA was calculated in the same manner for both carcinogens and noncarcinogens. The dose absorbed per unit area per event (DA) is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. If it is assumed that the concentration gradient across all of the skin layers is constant and the rate that a chemical enters the skin equals the rate that it exits, DA can be estimated using the following steady-state equation:

$$DA = Cw * CF * PC * ET$$

where

DA	=	dose absorbed per unit area per event (mg/cm ² -event),
Cw	=	chemical concentration in water (mg/L),
CF	=	volumetric conversion factor for water (1 liter/1000 cm ³),
PC	=	chemical-specific dermal permeability coefficient (cm/hr), and
ET	=	exposure time (hours/event).

USEPA (1992b) has identified a nonsteady-state approach to estimate the dermally absorbed dose from water and has recommended that it be used over the more traditional steady-state approach described above. This approach accounts for the total amount of chemical crossing the exposed (outside) skin surface rather than the amount which has traversed the skin and entered the blood during the exposure period (i.e., under a steady-state condition). Therefore, the nonsteady-state approach more accurately reflects normal exposure conditions (under which steady state often may not occur) and accounts for the dose that may enter the circulatory system after the exposure event due the storage of chemicals in skin lipids (USEPA 1992b).

The nonsteady-state approach has been developed for organics for which octanol-water partitioning data are available, thus was applied to the organic chemicals of concern identified in this assessment. As a comparable nonsteady-state approach has not been developed for inorganics, the assessment of dermal exposures to inorganics in water relied on the traditional steady-state equation shown above.

The equations applied to derive (DA) using the nonsteady-state dermal dose model were dependent on the length of assumed exposure time (termed ET) in relation to the time required after initial contact of a chemical with the skin for steady-state to be achieved (termed t^*). The assumed exposure time for contact with water is dependent on receptor behavior (e.g., it was assumed that 6-16 year old children would contact surface water for 1 hour on each of the days that they played in the Sequoit Creek). t^* is dependent on chemical-specific properties, and the appropriate equation to derive t^* for a chemical is dependent on a dimensionless constant reflecting the partitioning properties of that chemical (USEPA 1992b). This constant, termed B, can be derived from the octanol-water partition coefficient ($K_{o/w}$) as follows:

$$B = \frac{K_{dw}}{10^4}$$

Once B has been derived, t^* can be calculated using the appropriate equation.

If $B \leq 0.1$, then:

$$t^* = 2.4 * \tau$$

where

τ = lag time (hr)

If $0.1 < B < 1.17$, then:

$$t^* = (8.4 + 6 * \log B) * \tau$$

If $B \geq 1.17$, then:

$$t^* = 6 * (b - \sqrt{b^2 - c^2}) * \tau$$

where

$$b = \frac{2}{\pi} * (1 + B)^2 - c$$

$$c = \frac{1 + 3 * B}{3}$$

The lag time (τ) is defined for the stratum corneum, the outermost layer of the skin, which is thought to provide the major resistance to the absorption into the circulatory system of chemicals deposited on the skin (USEPA 1992b). τ can be derived from the following equation:

$$\tau = \frac{l_{sc}^2}{6 * D_{sc}}$$

where

l_{sc} = thickness of stratum corneum (10^{-3} cm), and

D_{sc} = diffusivity of a chemical within the stratum corneum (cm^2/hr).

The diffusivity of a chemical within the stratum corneum (D_{sc}) can be estimated from the thickness of the stratum corneum (l_{sc}) and the molecular weight (MW) of the chemical using the following equation:

$$\text{Log} \frac{D_{sc}}{I_{sc}} = -2.72 - 0.0061 * MW$$

Once the time until steady-state (t^*) has been derived, it can be compared to the assumed exposure time (ET) in order to select the appropriate equation to derive the dermal dose (DA). If the exposure time was less than the time until steady-state (i.e., if $ET < t^*$), the following equation was used:

$$DA = 2 * C_w * CF * PC * \sqrt{\frac{6 * \tau * ET}{\pi}}$$

where

- DA = dose absorbed per unit area per event (mg/cm²-event),
- C_w = chemical concentration in water (mg/L),
- CF = volumetric conversion factor for water (1 liter/1000 cm³),
- PC = chemical-specific dermal permeability coefficient (cm/hr), and
- ET = exposure time (hours/event).

If the exposure time was greater than the time until steady-state (i.e., if $ET > t^*$), then the following equation was used:

$$DA = C_w * CF * PC * \left[\frac{ET}{1+B} + 2 * t^* * \frac{1+3*B}{1+B} \right]$$

Chemical-specific dermal permeability coefficients represent the rate at which chemicals penetrate the skin. These were presented in the main text.

C.7 REFERENCES

- U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1986. Guidelines for Carcinogenic Risk Assessment. Fed. Reg. 51:33992-34003
- U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1989. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. Interim Final. OSWER Directive 9285.7-01a. September 29, 1989
- U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1992a. Guidelines for Exposure Assessment. Fed. Reg. 57:22888-22936. May 29, 1992
- U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1992b. Dermal Exposure Assessment Principles and Applications. Interim Report. Office of Research and Development, Washington D.C. EPA/600/8091/011B

APPENDIX D

**INFORMATION ON THREATENED AND ENDANGERED SPECIES
IN THE STUDY AREA**



Illinois Department of Conservation

LINCOLN TOWER PLAZA • 524 SOUTH SECOND STREET • SPRINGFIELD 62701-1787 CHICAGO OFFICE • ROOM 4-300 • 100 WEST RANDOLPH • CHICAGO 60601

Brent Manning, Director

John W. Comerio, Deputy Director

Bruce F. Clay, Assistant Director

November 30, 1993

Ms. Judi L. Durda
Weinberg Consulting Group Inc.
1220 Nineteenth Street, NW, Suite 300
Washington, D.C. 20036-2400

RE: Antioch Landfill, Lake County
Threatened and Endangered Species Review

Dear Ms. Durda:

Thank you for sending the above project to this office for review for the presence of endangered or threatened species or natural areas. The Natural Heritage Database was examined and there are several known occurrences of endangered and threatened species and Illinois Natural Area Inventory sites within the vicinity of the project area, as mapped and below:

Loon Lake-East Loon Lake Natural Area

Notropis anogenus, pugnose shiner, IL Endangered

N. heterodon, blackchin shiner, IL Threatened

N. heterolepis, blacknose shiner, IL T proposed E

Fundulus diaphanus, banded killifish, IL T

F. dispar, starhead topminnow, IL watchlist

Chlidonias niger, black tern, IL E and Fed. category 2

Potamogeton robbinsii, fern pondweed, IL E

P. gramineus, grass-leaved pondweed, IL E

P. praelongus, white-stemmed pondweed, IL E

Etheostoma exile, Iowa darter, IL T proposed E

Beckmannia syzigachne, American slough grass, IL E

Deer Lake-Redwing Slough Natural Area/Redwing Slough State
Natural Area

Podilymbus podiceps, pied-billed grebe, IL E proposed T

Gallinula chloropus, common moorhen, IL T

Xanthocephalus xanthocephalus, yellow-headed blackbird, IL E

Ixobrychus exilis, least bittern, IL E

Grus canadensis, sandhill crane, IL E

Carex viridula, little green sedge, IL E

Antioch Bog Natural Area

Larix laricina, tamarack, IL T

The map shows rough boundaries of Natural Areas, as well as indicating A for animal and P for plant. Numerals before the A or P indicate multiple species in the same location.

Please be aware that the Natural Heritage Database cannot provide a conclusive statement on the presence, absence, or condition of significant features in any part of Illinois. The reports only summarize the existing information regarding the natural features or locations in question known to the Division of Natural Heritage

at the time of the inquiry. The reports should not be regarded as final statements, nor should they be a substitute for field surveys required for environmental assessments.

I cannot charge you for the search of our database, but I would like to urge your support of the Illinois Natural Heritage Database by contributing to the Illinois Wildlife Preservation Fund. The recommended donation for this information request is \$60.00. Such contributions may be mailed to the above Springfield address. We appreciate your support of this important source of information.

If you have any questions, please feel free to call me at 217/785-8290.

Sincerely,

A handwritten signature in cursive script that reads "Susan E. Dees".

Susan E. Dees
Endangered Species Protection Program
Data Manager

cc: Charlene Falco, Illinois EPA

